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Heating · Piping and Air Conditioning

Installation
Maintenance
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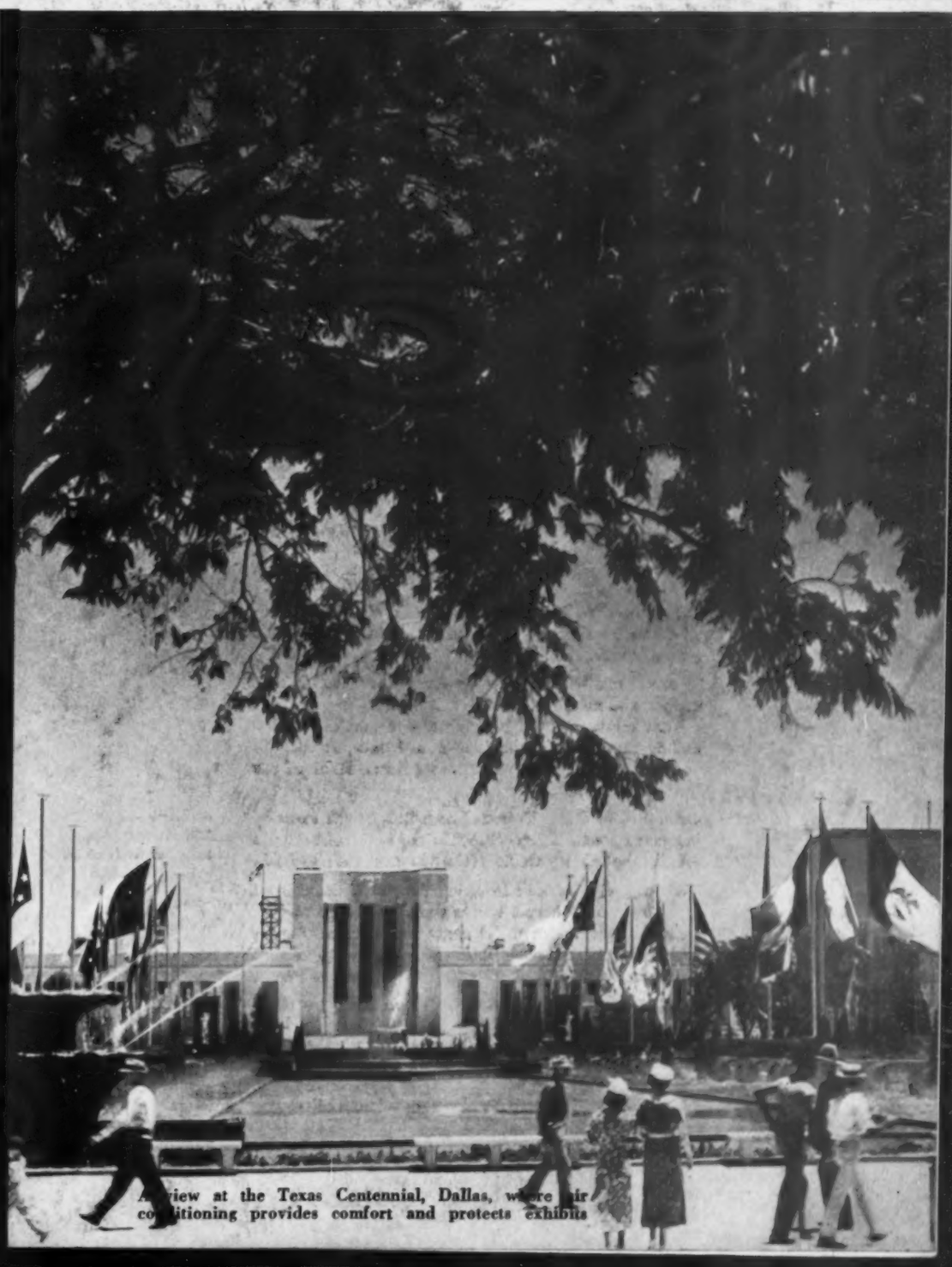
ST. 1936

Section of
of Heating
Engineers



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THE EDITOR'S PAGE • August, 1936

■ Air conditioning quite naturally came in for a great deal of attention during last month's heat waves and stimulated business for many an air conditioned theater, restaurant, store and hotel. Several movie theaters announced that they would remain open all night and that patrons could avail themselves of the advantages of air conditioning, if not of a bed. One woman was observed to enter a theater, spread a cloth on an antique table in the lobby, unpack a lunch which she and her children ate in air conditioned comfort. . . . *Advertising Age* pointed out that consumers nowadays can shop normally in extremely hot weather, women especially seeming to realize they are better off shopping in air conditioned stores than staying at home. . . . The same publication reported that William H. McLeod, sales manager of William Filene's Sons Co., Boston, characterized their air conditioning installation as "one of their finest institutional advertising features."

■ *Paul R. Unger's and Kalman Steiner's article on what the operating engineer should know about the combustion process and boiler efficiency, published last month, is one of the best and most important papers published in a long time on this subject, concluded one reader of* HEATING, PIPING AND AIR CONDITIONING *after studying it over several times.*

■ Air conditioning is becoming a popular subject for newspaper editorial writers. The Decatur (Ill.) *Herald* pointed out in an editorial last month that air conditioned business establishments reaped their reward for their enterprise in installing air conditioning equipment during the record high temperatures, speculated on the air conditioning of "all outdoors." . . . The Chicago *Tribune* labeled air conditioning "Private Initiative Works Project No. 1" in an editorial published during the heat wave, called air conditioning the "Moses of the present depression," because of the man-hours of labor it has produced. Stressing the advantages of air conditioning, the writer pointed out that an air conditioning system is an *investment* and not an expense. . . . The Commonwealth Edison Co., Chicago, reports that the first six months of 1936 were the largest in its air conditioning history, with more than 225 jobs installed or contracted for, adding 4,280 kilowatts to the actual or potential connected load. This is a 25 per cent increase over the number of installations for the corresponding period of last year. . . . Pixley & Ehlers, Chicago restaurant chain, is the first chain of self-service restaurants to have all its units air conditioned, according to A. Boyd Pixley, vice-president. Approximately a quarter of a million dollars has been spent in conditioning the thirteen units.

■ *M. E. Leeds, president of Leeds & Northrup Co., Philadelphia, was awarded the Henry Laurence Gantt gold medal for "distinguished achievement in industrial management as a service to the community" by the Institute of Management at a joint dinner of the Institute and the American Management Association at New York in June. . . . F. L. Riggin was recently named president of Mueller Brass Co., Port Huron, Mich., succeeding Oscar B. Mueller, who has retired from active management. Mr. Riggin was formerly executive vice-president of the company. . . . Minneapolis-Honeywell Regulator Co. has announced an extensive national advertising program starting this month, which will emphasize to consumers the advantages of the immediate installation of air conditioning and automatic heating equipment.*

■ Both the accident frequency and accident severity rates in the sheet metal industry were lower in 1935 than in 1934, according to the National Safety Council, Inc., 20 N. Wacker Drive, Chicago, which has recently issued a 22 page report on accident rates in the metal products industries. The report was assembled from data from 179 plants, whose employees worked a total of 129,414,000 man-hours. . . . A completely electrified dairy farm with many novel features was formally opened last month, has been prepared for exhibit before delegates to the World Power Conference to be held in Washington in September. Among the features are an air conditioned farmhouse, electrically charged screen to electrocute flies, a single wire fence with a light electric charge to keep the livestock in bounds. Cows are milked electrically. . . . A national advisory committee on toxic dusts and gases has been brought together under the auspices of the American Standards Association, will determine threshold limits beyond which toxic dusts and gases are dangerous to workers. According to the A. S. A., development of adequate standards in this field will protect employees from unhealthful working conditions and industrial concerns from racketeering in liability cases.

■ *According to S. F. Myers, Westinghouse manager of air conditioning sales, it is no longer the retail merchant's problem as to how long he will be able to get along without air conditioning, but how long he will be able to remain in business without it. . . . With the acceptance of air conditioning has come a better understanding of what really is required in air conditioning, he believes. He points out that every job is different and that a system must be properly engineered to fit it, giving as an example one installation selling for an installed price of $8,954, which required an original engineering contact, preliminary survey, contacting architect, preliminary drawing, preparation of estimate, preparation of proposal, contracting owner, architect and tenant, final survey, and final drawings. This represented a total time consumption of 160 man-hours with a cost in direct time and materials of $300, not including some selling expense and engineering adjustments. Because this installation was properly engineered, the purchaser received a system that was entirely satisfactory, and can be profitably written off in a short period or be offset by other advantages.*

■ A contract for air conditioning the duPont office building in Wilmington, Del., was awarded York Ice Machinery Corp., it was announced last month. One of the largest orders of the year, it involves some 600 tons of refrigeration, and equipment to condition 167,000 cfm. . . . The Sherwin-Williams Co. has announced it will air condition its plants, primarily for the comfort and efficiency of its employees. . . . The Indianapolis Electric League is stressing the advantages of general office air conditioning to Indianapolis office building owners and managers with an exhibit of "the correct office," located in the heart of the Indianapolis business district. . . . Thirty railroads which have been studying the railway air conditioning problem will ask the traveling public to submit views on the efficiency of equipment now in use on passenger trains by means of a questionnaire to be distributed to passengers. Some criticisms which have been received indicate objections to air conditioning cars at night and not in the daytime, and not air conditioning all the cars in the train.

■ *The increasing number of air conditioning installations not only complicates the question of water supply, as in New York, but that of water disposal as well. In downtown Chicago, where small sewers built many years ago were already severely over-loaded, the situation has become acute, may force building new sewers, lead to the wider use of cooling towers or some other solution.*

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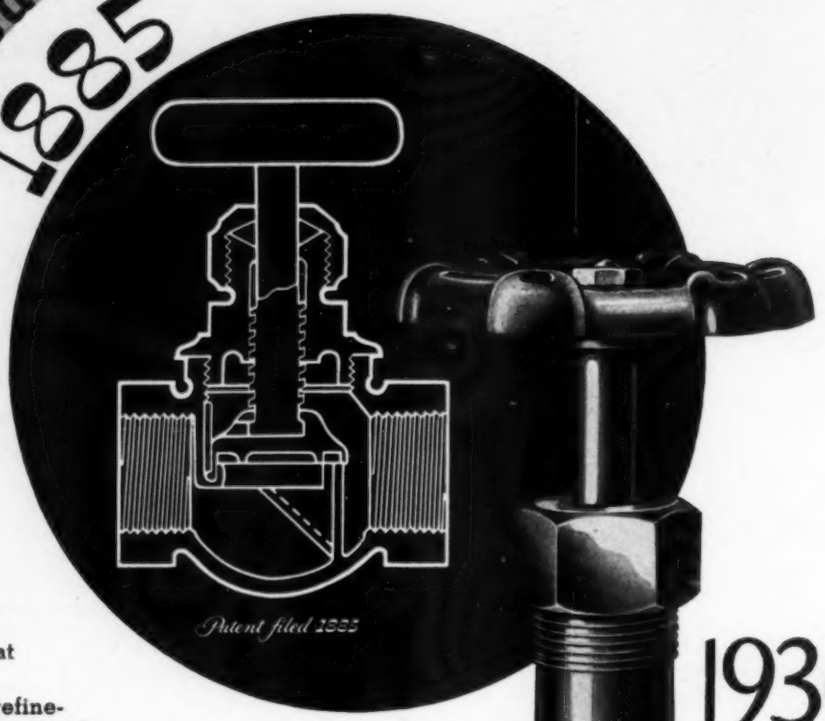
1885



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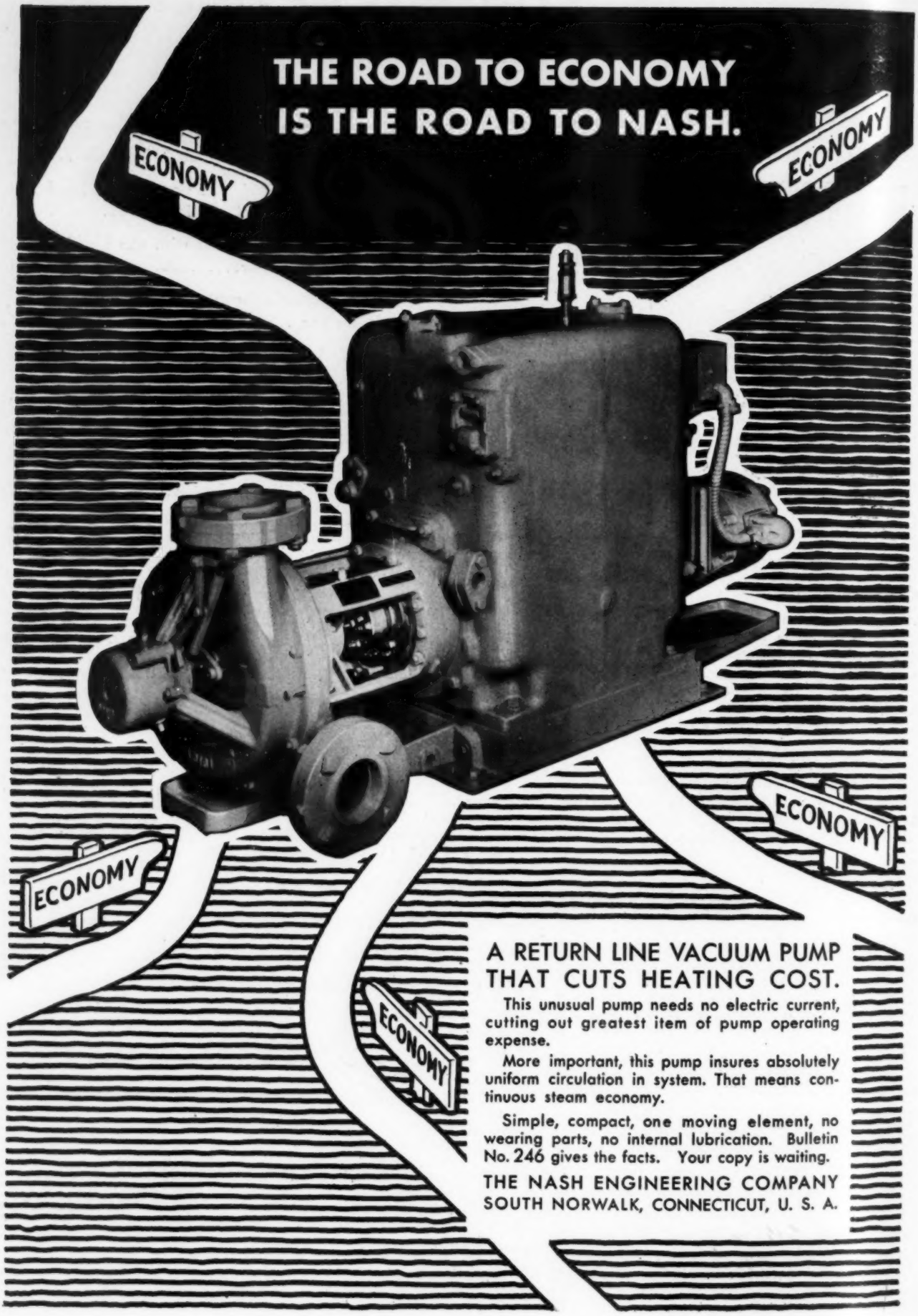
THE ROAD TO ECONOMY IS THE ROAD TO NASH.



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Heating · Piping
and Air Conditioning

Vol. 8, No. 8 • *August, 1936*

Air Condition the Bakery Throughout

says W. W. Reece,* bakery engineer.
Cites reasons, what to consider

THERE are three generally accepted and proved applications of air conditioning in baking plants: (1) Automatic humidification of fermentation rooms, (2) automatic humidification of proof boxes, and (3) the cooling of bread. There are many more installations of this kind today than there were ten years ago, we know the results that can be had, and we know that an investment in air conditioning equipment to perform these services saves money. It is my measured thought that the day has now arrived when *general air conditioning* of bakeries must be accepted.

The accompanying layout, Fig. 1, should not be considered a typical plant, particularly, but rather it is the layout of a plant for Phoenix, Arizona, now in design and which is used here as an example to bring out our thought on some of the fundamentals which must be considered in order that general bakery air conditioning may be practicable. The plan is for a one story bakery which fronts 150 ft on the street and is about 140 ft deep back to the alley. Average ceiling height is approximately 12 ft. It is laid out for complete air conditioning; I think it would be a mistake to try to build a bakery for this climate any other way.

Briefly, this is the flow of operations from the upper left-hand corner at the alley; the receipt of materials into the storage room and then to the mixers, from there to an enclosed inside fermentation room in the lower left-hand corner, then to the make-up unit in the front of the plant, the proof box, a tray oven or a reel oven, by conveyor back to a conditioned wrapping enclosure, to the wrapping machines, out to the packing department, and loading. The offices, employees' toilet and locker rooms are on the right-hand side of the plant.

Air Conditions Required

I will point out first what I call the three accepted applications of air conditioning, namely, the fermentation room, the proof box and conditioned bread cooling and wrapping. This fermentation room is of the enclosed type with a low ceiling, paneled construction, entirely cut off from the outside walls, easy to refrigerate, easy to maintain. Insulation expense is not costly. That is to be maintained by a separate unit at 78 F and around 75 per cent relative humidity, as is noted on the drawing.

The conditioned proof box in the center is of the usual panel construction, to be conditioned to 95 F and 85 per cent relative humidity.

The bread cooling tunnel of the usual panel construction with a conditioner on top, is to be maintained at 75 to 80 F and around 85 per cent relative humidity. The wrapping enclosure with a separate conditioner and duct distribution system, is to be conditioned to 70 to 80 F and 50 to 60 per cent relative humidity.

We will now consider the general conditioning of this plant. The flour storage, with a separate conditioner, is to be maintained at 78 F and 70 to 75 per cent relative humidity. Theoretically, at least, 75 per cent is correct for the storage of flour; at that humidity, flour will retain its normal moisture content and will best preserve its quality.

The make-up department and the offices and washrooms are to be conditioned from a central conditioner. The make-up department, cut off by partitions from the oven room space, is to be conditioned to 70 to 80 F and 50 to 60 per cent relative humidity, and that condition is to obtain throughout the make-up department, the offices and locker rooms.

Segregated Sections

The trick in being able to accomplish this best is to have a layout in which the sources of heat in the plant

The author, who has had a wide experience in bakery engineering and has served as chairman of the *American Society of Bakery Engineers* standardization committee, believes in the general air conditioning of bakeries. He describes here the requirements and fundamentals to be considered. . . . . Because general bakery air conditioning enables better control of the process and better working conditions, it is his conclusion that provisions for complete air conditioning should be incorporated in every design for a modern bakery

*Chief Engineer, W. E. Long Co., Chicago, Ill. From a paper presented at the recent W. E. Long Co. Conference of General Managers of bakeries.

are segregated. Those sources of extreme heat are the boiler, ovens, hot bread, hot pans, and the proof box. You will note that these are segregated in the center of the plant in a space that is to be ventilated, not air conditioned. The thought is that very few employees are going to be affected. There will be one or two oven men and a pan greaser working in that space and if there is a stream of cooled air that comes in near where they are working in front of the oven, this is as much as is practical to take care of them.

The loading room and repair shop are not conditioned. In that space, the loading room and in the oven room, the process is not affected.

Advantages of Air Conditioning

Mention was made of 50 to 60 per cent relative humidity. The thought is that we have gone a long ways in mechanizing bakeries, largely from a process standpoint. We talk a lot about employee efficiency and putting in this, that and the other thing to reduce labor costs.

General air conditioning helps in two ways—for whatever benefit it might be in the process and also for what part it can take in making employees more efficient, more helpful and happier. Good working conditions for em-

[*Concluded on page* 422]

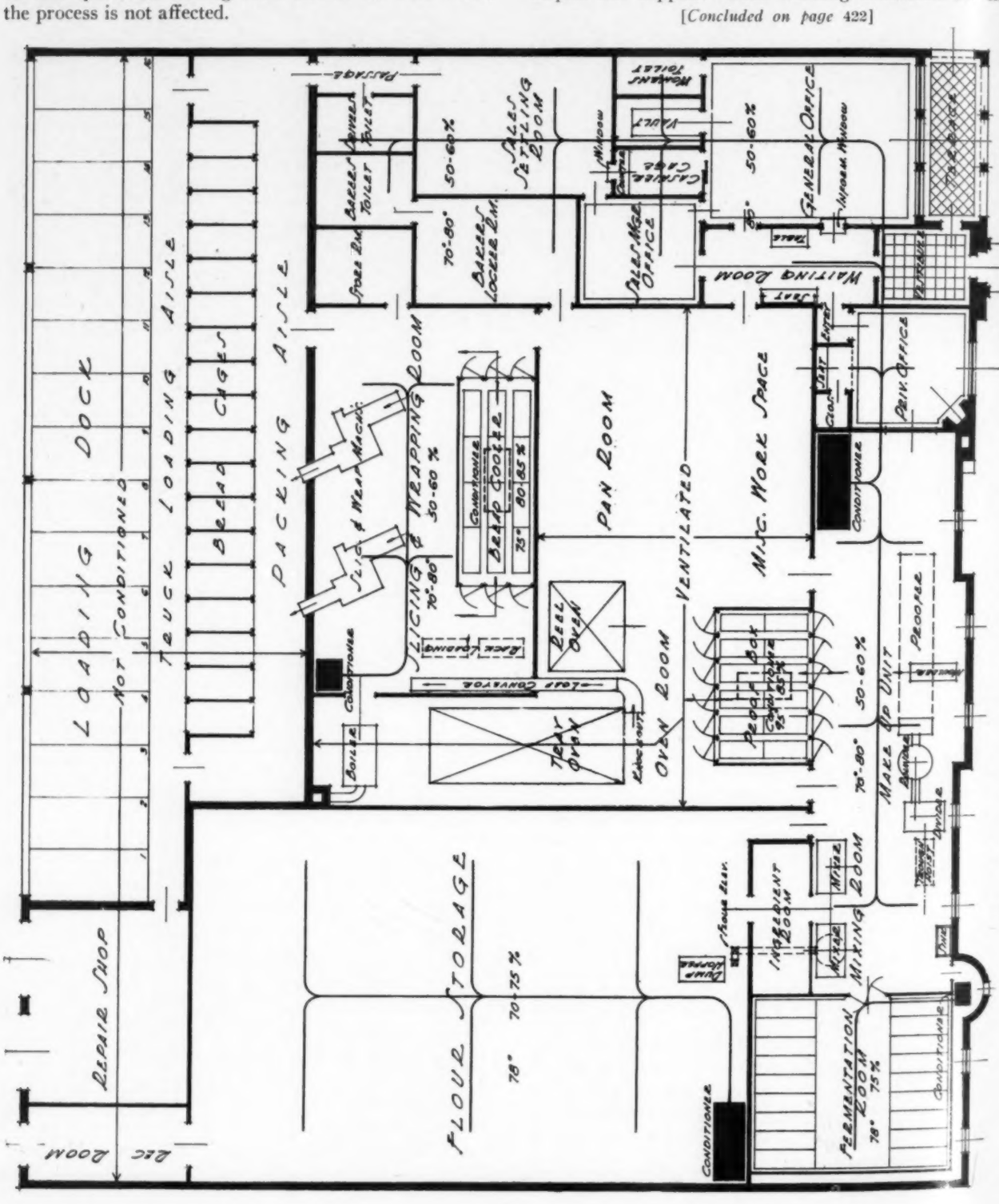
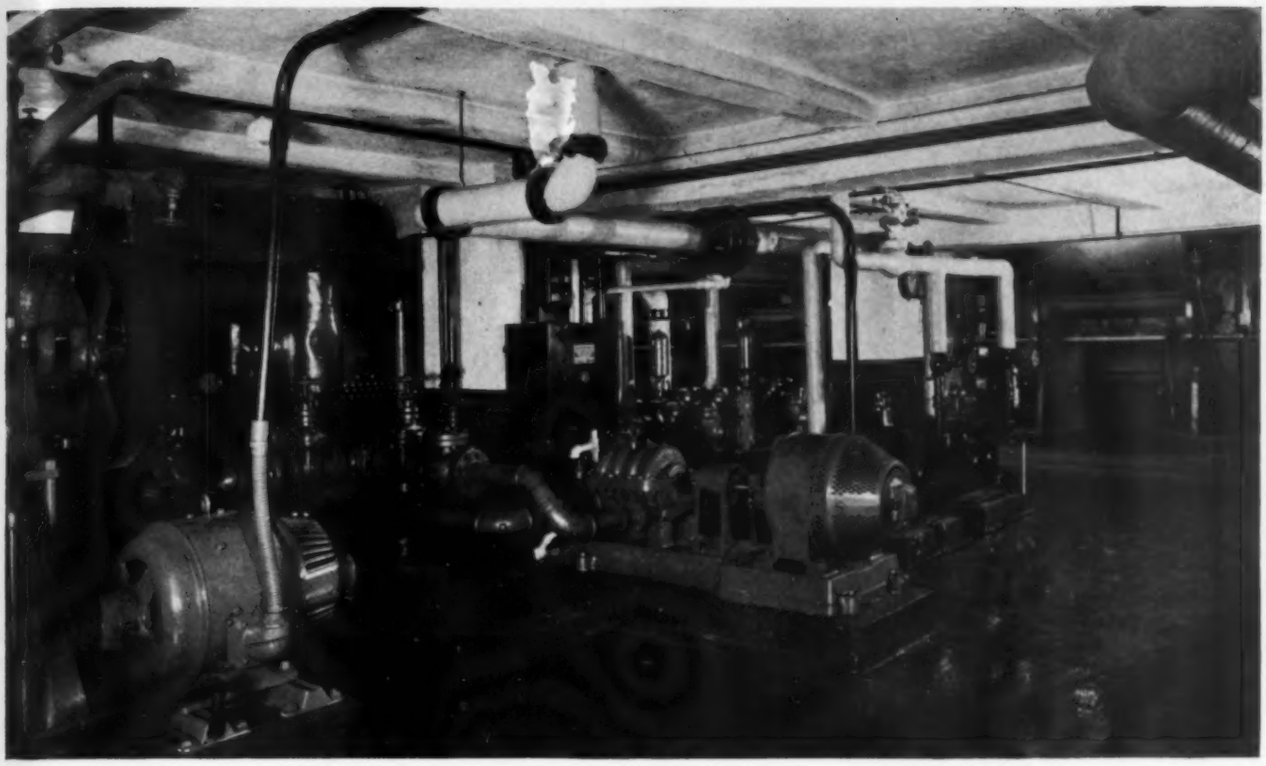


Fig. 1—Layout of a bakery equipped for general air conditioning, showing conditions to be maintained in each department. Capacity of bakery, 3000-5000 lb per hr



A clean, well painted, light boiler room is an indication of an efficient heating plant. Bright and shining is The Pure Oil Building's boiler room, for equipment is regularly painted, even the piping is dusted. Red is used for fire pumps, piping and other fire protection equipment—green for cold water lines and pumps—yellow for steam and hot water piping. Floor is maroon

Pure Oil Building Cuts Cost of Heating

By Clyde Maxwell*

. . . and proves that worthwhile opportunities for heating economy exist even in a comparatively new building

THERE are very few heating systems in operation today where opportunities to achieve worthwhile economies in cost of operation do not exist. Heating costs tend to increase unless the operating staff is eternally vigilant, and if maintenance is neglected. Frequently, the proper instruments, meters and other facilities for obtaining performance data are not available; sometimes, sad to say, such equipment is at hand but is not used as it should be.

That worthwhile economies are often possible if a thorough survey is made to disclose them is proved by the past ten years' experience at the Pure Oil Building, Chicago, where annual savings of over $17,000 are estimated to have been made. The record of heating plant operation from May, 1926, to May, 1934, discloses a steadily increasing cost of fuel and a corresponding increase of labor cost. Moreover, the increasing costs had no direct relation to occupancy, as occupancy declined from January 1, 1929, until 1934. In May, 1934, John R. Fugard was appointed manager of the property, and observing that heating cost was far in excess of rented area demand, ordered a detailed survey of fuels and equipment.

The boilers were inspected thoroughly and various methods of operating the stokers were tried. Tests of fuel used in the past were made and new fuels and new fuel mixtures were tried out for size as well as to obtain the mixture of fine and coarse materials which would give greatest efficiency. Various boiler compounds were tested. Radiators, valves and mains were thoroughly inspected. Before reconditioning, a 10 hr test was run; see Table 1.

Rehabilitation of the Boilers—Scale averaging 3/8 in. in thickness was removed from the boiler tubes, the ignition arches were thoroughly repaired, and the wing arches were removed from the bridge wall in order to increase boiler capacity from 125 to 190 per cent of rating.

Radiators and Traps—Of a total of 1,600 radiator traps, 350 diaphragms had deteriorated so that steam was blowing straight through. The steam header traps from the boiler were completely eaten away and a check dis-

*Supervising Engineer, The Pure Oil Bldg., Chicago, Ill.

closed that exhaust wasted to atmosphere the year 'round was at the rate of 100 hp per hr. All defective traps and valves throughout the entire system were repaired and the flow meter was carefully checked.

Pumping Water—Nature of the tenancy required uninterrupted service. Formerly water was pumped by

The twelve-year-old Pure Oil Building

steam and electricity for the entire 42 floors. During plant changes a 40 hp, 250 gpm pump was installed to lift the water to the 25th floor and another 15 hp pump was installed to lift the water from the 25th to the 42nd floor. Both pumps are electrically driven. All steam pumps were removed with a corresponding saving in fuel consumption. It was then possible to discontinue boiler room operations from 8:00 p. m. to 7:00 a. m. for five months of the year, with savings in labor charges.

Table 1—Results of 10 Hr Tests Before and After Rehabilitation

	Before		After	
Coal burned	26,000	lb	19,342	lb
Evaporation	5	lb	7.09	lb
Ash	8	per cent	7.83	per cent
Volatile	33	per cent	31.09	per cent
Carbon	50	per cent	52.03	per cent
Sulphur	2	per cent	1.85	per cent
Moisture	7	per cent		
Btu per lb	12,000		12,314	
CO_2	5	per cent	12	per cent
Efficiency	41	per cent	62.3	percent
Steam generated	130,000	lb	130,500	lb

Water Treatment—Boiler treatment, as well as hot water heater treatment, was changed to a prepared treatment, which has proved beneficial in removing scale as well as in preventing scale from forming, and a net saving in costs in excess of $2,000 per year resulted. Elimination of the free oxygen condition existing in the boiler feed and in the hot water system effected a reduction in maintenance cost of $150 per month.

After rehabilitation of the plant, a second 10 hr test was run; the results are tabulated in the second column of the table. Thus, at a total cost of $3,000 (which represents the over-all expenditures) plant efficiency was greatly increased, and considerable savings in fuel cost, water system maintenance, and boiler room labor charges were obtained. Actual operation has proved the average annual savings to be for fuel, $13,000; cost of water system maintenance, $1,800; boiler room labor savings, $2,460; or total net savings of over $17,000. In addition, tenant complaints have been eliminated and occupancy has increased.

The same opportunities for achieving economies exist in many plants and buildings. The requirements are a thorough survey of the system, the proper facilities—such as instruments and meters—for obtaining specific data, and the realization on the part of the management that a wisely planned investment in heating plant improvement is returned many times over in lowered operating costs.

Air Condition the Bakery Throughout—

[*Concluded from page* 420]

ployees call for a relative humidity not higher than 50 to 60 per cent.

Temperatures of 70 to 80 F, or 10 to 15 F below the outside temperature, have been a debatable point. There is a lot of argument between air conditioning engineers, ventilating engineers, the medical profession, as to what is the proper temperature. The best agreement today, I believe, is that there should not be too wide a range between the outside temperature and the temperature under which the man is working.

Under uniform temperature conditions, flour storage should be maintained at a normal moisture content, in order to have a uniform aging and so that uniformity of quality of the finished product will be better insured because of the stable condition of the flour when it reaches the mixers.

There should be a very great improvement in the handling of the make-up process. The bakery is making a perishable product and if the temperatures rise unduly, the character of that product changes. When products are made up under uniform conditions, the uniformity of quality will be much better maintained. I would expect the employees in this make-up department to be more efficient and to be productive of more and better work.

In the office, the conditions will have been made better for the office help, while management will be working under better conditions.

"The public belief that air conditioning prices are going to decrease during the next few years is a fallacy," said M. J. Stevenson in a speech before the Air Conditioning Bureau of Omaha, reported in *The Business Conditioner*, published by the Bureau.

The cost of copper, electric motors, fans, sheet metal, and other equipment used in air conditioning is rising, according to Mr. Stevenson. "As a result, many prospective buyers of air conditioning equipment will be disappointed when they are asked to pay more next year than they would have paid in 1936."

Solving Stresses in Piping Offsets Subject to Compressive Load from Expansion Joints

By A. R. Pettit*

Exact calculation of stresses in piping offsets where the offset is subject to considerable compressive load from an expansion joint is a long and tedious job. The author presents a short method of calculation which saves time and gives reasonably correct results. Following the explanation of the method, an example is given comparing the results of the short with the grapho-analytical method

THE exact calculation of stress problems in piping offsets such as that shown in Fig. 1, in which the offset is subject to considerable compressive load from expansion joints, is a long and tedious job. The following short method of calculation is offered with the thought that it will save considerable time and yet give reasonably correct results. Its results compare favorably with those of the grapho-analytical method and are sufficiently accurate when it is considered that the compressive force caused by the expansion joint is variable. This compressive force, which is caused by the unbalanced steam pressure on the end of the expansion joint slip and by the packing friction, varies with steam pressure, kind of lubrication, frequency of lubrication, and tightness of packing ring adjustment.

Fig. 2 shows a typical offset with alignment guides at each end and a roller support with a special saddle at the middle. The guides must be kept as close as possible to the offset to keep stresses to a minimum. The roller support at the middle may or may not be needed, depending upon the length of the offset. The purpose of the special saddle is to support the pipe without forcing it upward or permitting it to sag when the offset moves under expansion.

The maximum bending stress in the offset, S_b, is obtained from the equation

$$S_b = S_e + S_k + S_w \quad \text{(Offset in vertical plane)}$$
$$S_b = [(S_e + S_k)^2 + S_w^2]^{\frac{1}{2}} \quad \text{(Offset in horizontal plane)}$$

S_e is the stress due to the expansion which takes place in the rise H of the offset. It is obtained by assuming the offset a constrained cantilever deflected by the amount of expansion in the H length, and expressed by the equation

$$S_e = \frac{6\,Ey\Delta}{(L+2M)^2}$$

where E = modulus of elasticity, y = outer radius of pipe in inches, Δ = expansion in inches for the H length, and L and M are lengths from Fig. 2 expressed in inches.

S_k is the stress due to the compressive force from the expansion joint. As the force acts so close to the alignment guide the stress is obtained by assuming the portion M as a plain cantilever, and its equation is

$$S_k = \frac{HF_xM}{NZ}$$

where F_x = compressive force due to the expansion joint and friction of supports and guides in pounds, Z = the section modulus of the pipe, and H and N are lengths from Fig. 2 expressed in inches.

S_w is the stress due to the weight of the pipe and its insulation, and is figured by assuming the offset as a straight horizontal beam fixed at both ends and uniformly loaded. The equation for this stress is

$$S_w = \frac{w(0.5\,L+M)^2}{144\,Z} \quad \text{(with roller support at middle of offset}$$

$$S_w = \frac{w(L+2\,M)^2}{144\,Z} \quad \text{(with no roller support at middle of offset)}$$

where w = the weight in pounds per foot of pipe and insulation.

The stress due to combined bending and compression is obtained from the long used combined formula and is expressed

$$S_c = \frac{F_x}{a} + \frac{S_b}{1 - \dfrac{F_x(0.5\,L+M)^2}{CEI}} \quad \text{(with roller support at middle of offset)}$$

$$S_c = \frac{F_x}{a} + \frac{S_b}{1 - \dfrac{F_x(L+2\,M)^2}{CEI}} \quad \text{(with no roller support at middle of offset)}$$

where a = cross sectional area of metal in pipe in square inches, C = a constant varying with end conditions of compression member, for which we use the value 8, and I = moment of inertia of the pipe.

The total stress in the offset is obtained by adding to S_c the longitudinal bursting stress produced by the pressure of the steam inside the pipe. The equation for the total stress is

$$S_t = S_c + \frac{P_sd}{4\,t}$$

where P_s = steam pressure in pounds per square inch gage, d = the internal diameter of the pipe in inches, and t = thickness of pipe in inches.

Example

The following sample problem, figured by both the short method and the grapho-analytical method, is given to show not only the saving in time by the use of the short method, but also the comparative results of the two methods.

Example: 6 in. standard pipe offset, with rise of 7 ft 9 in. in 40 ft 0 in., supported at the middle, with inside face of alignment guide spider 4 in. from intersection point. Steam is at a pressure of 175 lb ga and

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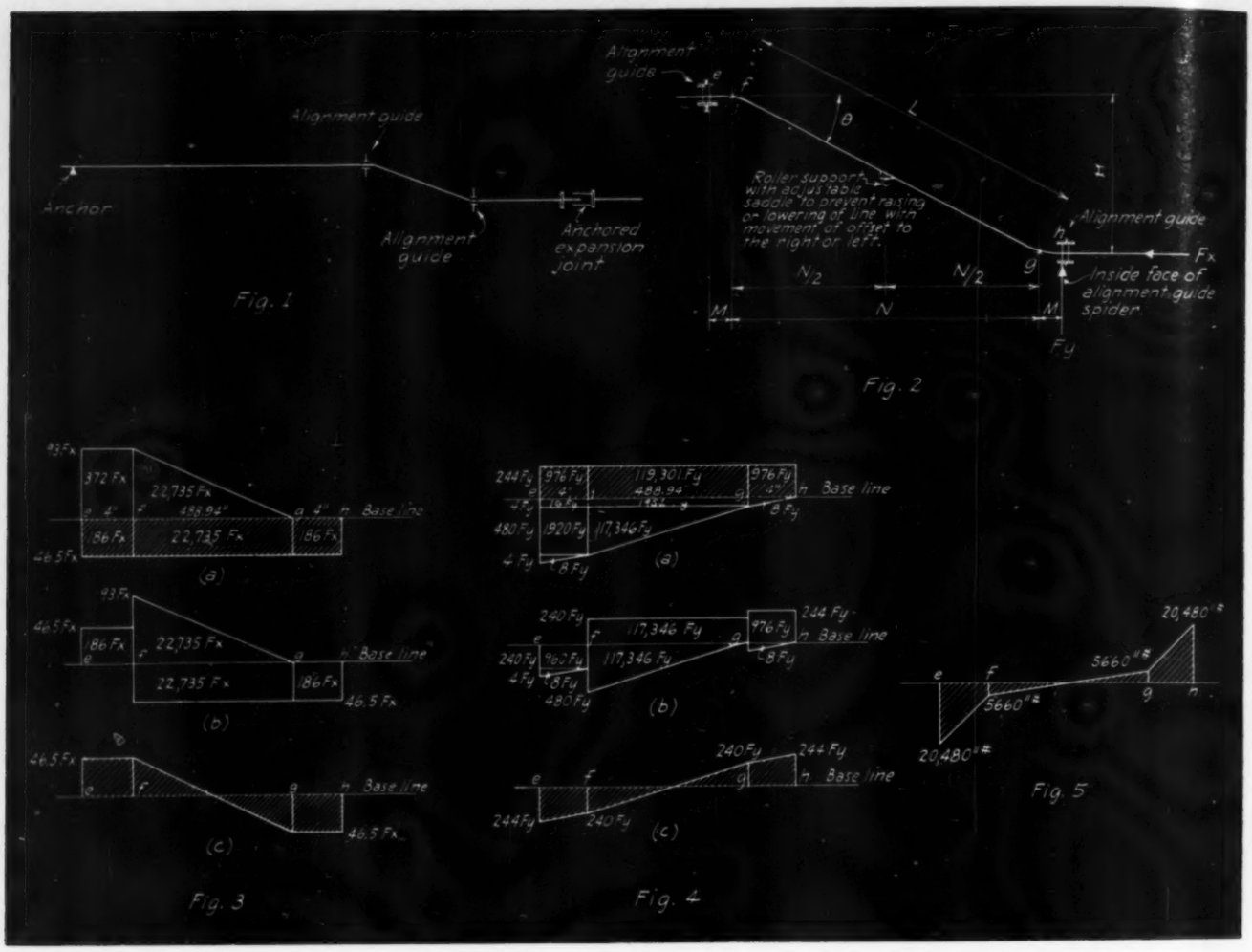


Fig. 1 shows the type of offset being considered, and Fig. 2 a typical offset used in the example; Figs. 3-5 are the diagrams for solving the problem by the grapho-analytical method

causes the pipe to expand at the rate of 4 in. per 100 ft. The pipe is insulated with double standard 85 per cent magnesia. Weight of pipe and insulation is 27 lb per ft. Compressive force = 19,000 lb.

6 in. standard pipe has a section modulus of 8.496, a moment of inertia of 28.14, an inside diameter of 6.065 in., an outside diameter of 6.625 in., a thickness of 0.28 in. and a cross sectional metal area of 5.581 sq in.

As $H = 7$ ft 9 in. and $N = 40$ ft 0 in., $L = 488.94$ in. and angle $\Theta = 10°\ 57'\ 54''$. $\Delta = 0.04 \times 7.75$ ft $= 0.31$ in.

By the Short Method:

$$S_s = \frac{6 \times 29{,}000{,}000 \times 3.313 \times 0.31}{(488.94 + 8)^2} = 723.6 \text{ lb per sq in.}$$

$$S_b = \frac{93 \times 19{,}000 \times 4}{480 \times 8.496} = 1{,}734.2 \text{ lb per sq in.}$$

$$S_w = \frac{27 \times (244.47 + 4)^2}{144 \times 8.496} = 1{,}362.7 \text{ lb per sq in.}$$

$$S_b = 723.6 + 1{,}734.2 + 1{,}362.7 = 3{,}820.5 \text{ lb per sq in.}$$

$$S_c = \frac{19{,}000}{5.581} + \frac{3{,}820.5}{1 - \dfrac{19{,}000 \times (244.47 + 4)^2}{8 \times 29{,}000{,}000 \times 28.14}}$$

$$= 3{,}404.4 + 4{,}657.3 = 8{,}061.7 \text{ lb per sq in.}$$

$$S_t = 8{,}061.7 + \frac{175 \times 6.065}{4 \times 0.28} = 9{,}006.7 \text{ lb per sq in.}$$

By the Grapho-Analytical Method:

Fig. 3 shows the diagrams developed from the action of force F_x (in Fig. 2) on parts *ef*, *fg* and *gh* of the offset. Part (a) is the moment assembly diagram, Part (b) the diagram used in figuring deflections, and Part (c) the resultant moment diagram. Fig. 4 shows similar diagrams developed from the action of force F_y.

F_x deflections are obtained as follows:

For *ef*	$EI\Delta_y = \psi_M M/2$	$= 186\,F_x \times 2$	=	372	F_x (down)
For *fg*	$EI\Delta_y = \psi_A L \cos\theta$	$= 186\,F_x \times 488.94 \times 0.98175$	=	89,100	F_x (down)
	$EI\Delta_x = \psi_A L \sin\theta$	$= 186\,F_x \times 488.94 \times 0.19021$	=	17,263	F_x (left)
	$EI\Delta_y = \psi_F(2/3)L\cos\theta$	$= 22{,}735\,F_x \times 325.96 \times 0.98175$	=	7,275,500	F_x (down)
	$EI\Delta_x = \psi_F(2/3)L\sin\theta$	$= 22{,}735\,F_x \times 325.96 \times 0.19021$	=	1,409,600	F_x (left)
	$EI\Delta_y = \psi_M(L/2)\cos\theta$	$= 22{,}735\,F_x \times 244.47 \times 0.98175$	=	5,456,750	F_x (up)
	$EI\Delta_x = \psi_M(L/2)\sin\theta$	$= 22{,}735\,F_x \times 244.47 \times 0.19021$	=	1,057,300	F_x (right)
For *gh*	$EI\Delta_y = \psi_A M$	$= 186\,F_x \times 4$	=	744	F_x (down)
	$EI\Delta_y = \psi_M M/2$	$= 186\,F_x \times 2$	=	372	F_x (up)

By Summation $EI\Delta_y = 1{,}908{,}594\,F_x$ (down)
$EI\Delta_x = 369{,}563\,F_x$ (left)
As $E = 29{,}000{,}000$, $I = 28.14$, and $F_x = 19{,}000$
$\Delta_y = 44.438$ in. (down)
$\Delta_x = 8.6044$ in. (left)

F_y deflections are obtained as follows:

For *ef*	$EI\Delta_y = \psi_F(2/3)\,M$	$= 8\,F_y \times 2.666$	=	21.33 F_y	(up)
	$EI\Delta_y = \psi_M M/2$	$= 960\,F_y \times 2$	=	1,920 F_y	(up)
For *fg*	$EI\Delta_y = \psi_A L\,cos\,\theta$	$= 968\,F_y \times 488.94 \times 0.98175$	=	464,670 F_y	(up)
	$EI\Delta_x = \psi_A L \sin\theta$	$= 968\,F_y \times 488.94 \times 0.19021$	=	90,026 F_y	(right)
	$EI\Delta_y = \psi_F(2/3)L\cos\theta$	$= 117{,}346\,F_y \times 325.96 \times 0.98175$	=	37,552,000 F_y	(up)
	$EI\Delta_x = \psi_F(2/3)L\sin\theta$	$= 117{,}346\,F_y \times 325.96 \times 0.19021$	=	7,275,500 F_y	(right)
	$EI\Delta_y = \psi_M(L/2)\cos\theta$	$= 117{,}346\,F_y \times 244.47 \times 0.98175$	=	28,164,000 F_y	(down)
	$EI\Delta_x = \psi_M(L/2)\sin\theta$	$= 117{,}346\,F_y \times 244.47 \times 0.19021$	=	5,456,750 F_y	(left)
For *gh*	$EI\Delta_y = \psi_A M$	$= 968\,F_y \times 4$	=	3,872 F_y	(up)
	$EI\Delta_y = \psi_F(2/3)M$	$= 8F_y \times 2.666$	=	21.33 F_y	(up)
	$EI\Delta_y = \psi_M M/2$	$= 976\,F_y \times 2$	=	1,952 F_y	(down)

By Summation $EI\Delta_y = 9{,}856{,}553\,F_y$ (up)
$EI\Delta_x = 1{,}908{,}776\,F_y$ (right)

Δ_y in this case, is equal to the 44.438 in. produced by F_x plus the expansion of 0.31 in. in the height H of offset, which is 44.748 in.

With $E = 29{,}000{,}000$ and $I = 28.14$

$$F_y = 3{,}704.8 \text{ lb}$$

Substituting the values of F_x and F_y in diagrams (c) of Figs. 3 and 4, and combining the two diagrams, the diagram in Fig. 5 is obtained. This diagram indicates that the maximum moments occur at each end of the offset. Dividing the maximum moment by the section modulus we get a stress of 2411 lb per sq in. This stress corresponds to the sum of $S_e + S_k$ by the short method, in which a figure of 2457.8 lb per sq in. was obtained. Using the same S_w as in the short method

$$S_b = 3773.7 \text{ lb per sq in.}$$

$$S_e = \frac{19{,}000}{5.581} + \frac{3{,}773.7}{1 - \dfrac{19{,}000 \times (244.47 + 4)^2}{8 \times 29{,}000{,}000 \times 28.14}}$$

$$= 3{,}404.4 + 4{,}600 = 8{,}004.4 \text{ lb per sq in.}$$

$$S_t = 8{,}004.4 + \frac{175 \times 6.065}{4 \times 0.28} = 8{,}949.4 \text{ lb per sq in.}$$

In this problem the total stress obtained by the short method is 0.64 per cent higher than that obtained by the grapho-analytical method.

It should be noted that in referring to the grapho-analytical method we refer mainly to the more exact method of obtaining the combined stress ($S_e + S_k$) under the same assumed conditions of the offset as for the short method.

Check Draft When Trouble-Shooting

When looking for boiler plant troubles, draft will be found to be at the seat of the difficulty in a surprising number of cases. The question of draft is tied up with the size of the coal and thickness of the fire. The right size of coal is sometimes more important than quality. A poor coal of exactly the right size to fit the load and draft, may give better results than a much higher grade coal of improper size.

Draft is directly affected by baffle openings, breechings and dampers, stack sizes, etc. A hole may develop in a baffle or a tile may fall down in such a way as to make the gas passage too free, or it may fall so as to obstruct the gases. A damper may get twisted on the stem and while indicating that it is wide open, it may be partly closed.

I know of one case where a plant operated for eight years with a master damper in the breeching ¾ shut and nobody even knew it was there. The stem had been twisted off and the breeching had been covered with lagging on the outside, hiding all evidence of the damper. A draft gauge pointed out where the trouble lay.—O. MONNETT, *in a paper on trouble-shooting at the University of Illinois short course on coal utilization.*

Air Conditioning for Health

THE effect of air conditioning on health and its uses in the treatment of diseases are considered by many to be the most important contribution of air conditioning to the future. While this aspect of the subject has not received the attention that industrial and commercial applications have been given, there is a growing appreciation of what the future of air conditioning may be in promoting health and happiness. Certainly, a great opportunity for serving humanity is offered.

In order to focus attention on what is now known of the medical and health aspects of air conditioning, and to stimulate thought on the future of such applications, contributions from authorities on the subject will appear regularly under this heading. Mr. Fleisher introduces this feature with some remarks on cooperation with the medical profession, and how the studies of the effects of air conditioning in pathological cases are of importance in comfort air conditioning work.

Cooperation with the Medical Profession

By **Walter L. Fleisher***

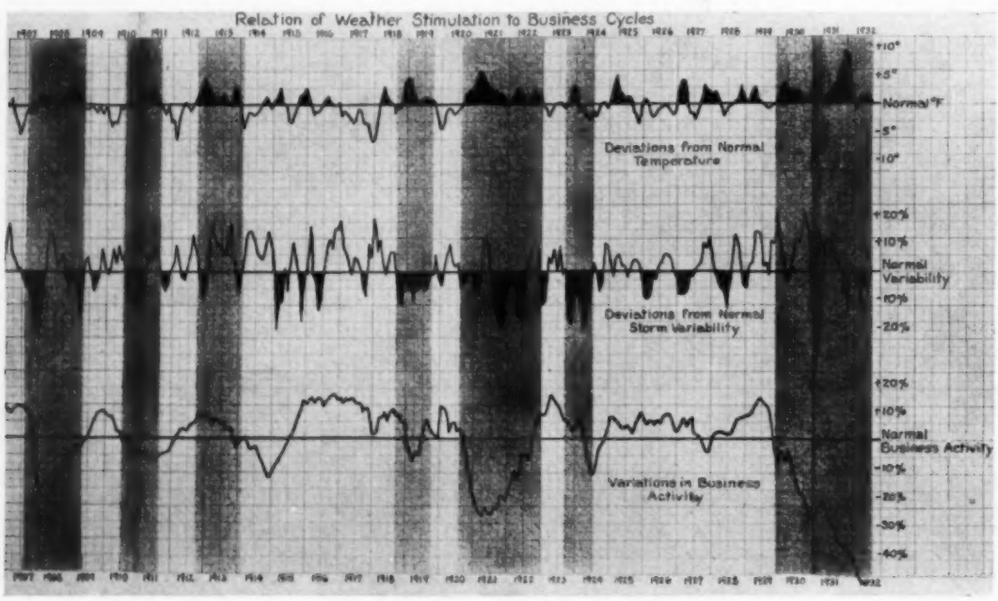
THE study of the abnormal often brings about an investigation of the normal, and so one great interest today in the cooperative movement with the medical profession as to the effects of air conditioning in pathological cases holds promise of knowledge that will instruct us in the approach to general "comfort" conditioning.

It is well to realize that the medical profession is divided into two groups (1) the welfare group, having to do with public health; that is, the health of the people as a whole, those who specialize in keeping people well. (2) The great medical group, who specialize in curing the sick. In our ordinary comfort air conditioning endeavors we must look to the former, and in our special developments, to the latter. For in general development of comfort conditioning, the New York Academy of Medicine, the life insurance companies, the great welfare foundations—like the Carnegie, the Rockefeller, the Millbank and the Russell Sage—can contribute most in money and in sympathy. In the investigation of air conditioning in disease—that is, the study of its application in tuberculosis, syphilis, arthritis, asthma, neuroses, common cold, cancer, hay fever and hypertension—we must learn through the variations of skin temperatures, oral temperatures, blood counts, blood pressures and nervous reactions, many of the important factors that affect our well being.

Dr. Mills of Cincinnati and Dr. Huntington of Yale have statistically indicated that the civilization of the world has been definitely affected by the climate in which people lived. As air conditioning for comfort becomes more and more of a necessity and we attempt more and more to obtain conditions close to the optimum without being able to affect the outside conditions into which we must pass, what is to be the effect on the future of our people with such wide and rapid variations? Is the good effect of these conditions to compensate for the rapid changes into worse conditions, or should we moderate our so-called best conditions to conform with the necessity of entrance into worse? These are all questions that only time can answer. But the scientific engineer has the advantage of being in constant touch with innumerable installations producing these so-called conditions and can observe and record the reactions of human beings to these conditions infinitely more easily than the medical profession. As the effects primarily are psychological and only secondarily pathological, he can, without fear, record his observations, and reason from them with as great assurance as the doctor, himself.

The opportunity for a great cooperative research movement not only affecting all human beings at the present time, but with the possibility of having major consequences on the future of the race was never as opportune as at the present moment.

*Consulting Engineer, New York, N. Y. Member of Board of Consulting and Contributing Editors.



Of interest as indicating the effect air conditions have on human beings is Dr. C. A. Mills' work on the effect of weather on man and business activity. Dr. Mills has shown that business activity, the determining factor of which is considered to be the level of human energy, in general is dependent on the effects of weather conditions on man. Two particular weather abnormalities have been found particularly depressive — an unusual drop in storminess or day-to-day temperature variability, and unseasonably high temperatures. Thus, cool weather and fluctuating temperatures mean good times. The graph shows the results of his studies

Pressure Losses in Rectangular Elbows

[PART 2]

By R. D. Madison* *and* J. R. Parker†

PART 1, published last month, presented a definition of the terms used, described the test apparatus and methods, and discussed the effect of the radius ratio.

Effect of Aspect Ratio

Elbows of various aspect ratios are shown in Fig. 4. The effect of aspect ratio for elbows of different radius

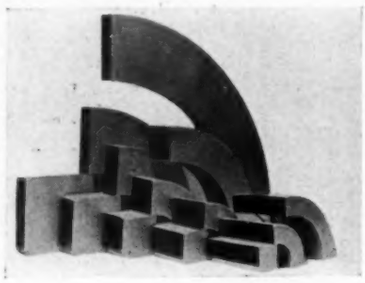


Fig. 4—Elbows of various aspect ratios

ratios is shown in Fig. 5. The curves in Fig. 5 are also plotted on the basis of curve ratio to show the effect of duct friction in the region of high curve ratios. It will be seen that there is a characteristic rise in the points in this region to meet the friction curve.

It is conceivable that if the friction curve *D*, Fig. 5, is subtracted from the total pressure curve *A* there will result a curve which, to some extent, represents shock loss. By using this as a base curve and cross-plotting shock loss differences with other aspect ratios, the values thus obtained can be united with their respective friction curves to obtain the most probable shape of the curves passing through actual test points. This procedure was used to obtain data in the zone of low radius ratios for aspect ratios other than unity. However, the resulting curves, Fig. 5, are not easily applicable from an engineering standpoint. The percentage curves shown in Fig. 6 have therefore been prepared, based on an aspect ratio of unity. It is clear from these curves that the loss is still a function of the radius ratio. However, it is readily seen that the two curves in Fig. 7, one for the higher radius ratios of 1 to 3, which are normally used, and another for the lower ratios, where the inside corner is substantially sharp, will closely approximate the data plotted in Fig. 6. It will be observed that the slope of curve *A* in Fig. 7 at an aspect ratio of unity is nearly horizontal and continues so through an aspect ratio of 3, approximately. Contrary to general opinion, there is little harm in using aspect ratios as low as 0.75. This tendency for the slope of curve *A* to reverse as it passes through unity has also been noted, and in even greater degree, in tests of large ducts. In testing 28 in. × 38 in. elbows with a radius ratio of unity, the loss was 5 per cent less for an elbow with a low aspect ratio (hard bend) than for an elbow with a high aspect ratio (easy bend). In applying such information to elbows using splitters, it dictates the position of the splitter or splitters in the elbow and indicates that the respective elbows formed by the splitters should have approximately the

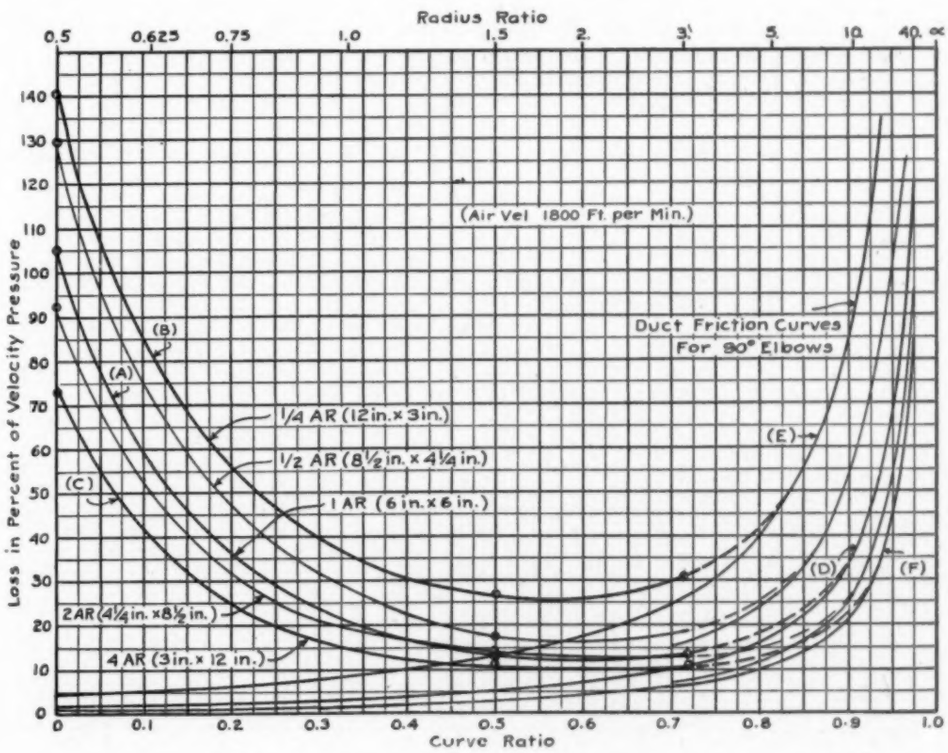


Fig. 5—Results of tests of 90 deg elbows showing the effect of aspect ratio

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†Engineer with Buffalo Pumps, Inc., Buffalo, N. Y.
Contributed by the Aeronautic Division and presented at the Annual Meeting of *The American Society of Mechanical Engineers* held in New York, N. Y., December, 1935. Published in *A. S. M. E. Transactions* for April, 1936.

same radius ratio. This will be discussed later in the paper.

Effect of the Degrees Turn of the Elbow

It has been assumed generally that the pressure loss through an elbow is directly proportional to the angle through which the turn is made. This is approximately true for 45 deg and 90 deg turns. If a large angle is used, there is a marked change in the proportionality as indicated by the curves in Fig. 8. This is not unreasonable in view of the fact that the air near the latter part of the turn has a flow materially different from that at the beginning of the elbow, which flow is assumed to be straight. During the first part of the flow in the elbow, a double spiral movement is formed which must be accelerated from zero. Later in the turn, the spiral movement has become more definitely established and requires less energy to maintain it. The curves in Fig. 8 show the effect of the degrees turn on the pressure loss in (1) an elbow with free discharge, (2) elbows followed by ducts, and (3) elbows with a splitter. These curves are based on tests of 12⅜ in. elbows having a radius ratio of 0.9 and an aspect ratio of unity. From the previously mentioned theory it would be expected that the curves become straighter, that is, the proportionality of the loss with the degrees of turn becomes more uniform as the curve ratio increases and the shock loss consequently diminishes.

The curves in Fig. 8 are factor curves for degrees turn only. Thus the loss in a 180 deg elbow with a splitter is not just slightly less than such an elbow without a splitter, but rather is slightly less in proportion than the loss in the respective 90 deg elbow; in both cases the splitter materially reduced the elbow loss as explained later.

Effect of Elbow Size

Size has very little effect on the pressure loss in most elbows. This is due to the fact that the loss due to the size of the elbow is principally a shock loss and is not greatly affected by duct friction. However, where the radius ratio is large or the aspect ratio small there is a greater effect. The curves in Fig. 9 show the losses in 3, 6, and 12 in. elbows, with an aspect ratio of unity and with varying curve ratios. The solid curves at the left (superposed upon each other below values of 0.4 curve ratio) are the actual elbow losses obtained by test, while the solid curves at the right are the respective losses due to duct friction only. The dashed lines give the approximate values necessary to blend these into continuous curves. The duct-friction curves are based on a coefficient of friction which is equivalent to one velocity head loss in 55 diameters of a 12 in. square duct and which varies inversely as the 1/7 power of the size (linear). Some of the elbows tested to show the effect of size on the pressure loss are shown in Fig. 10.

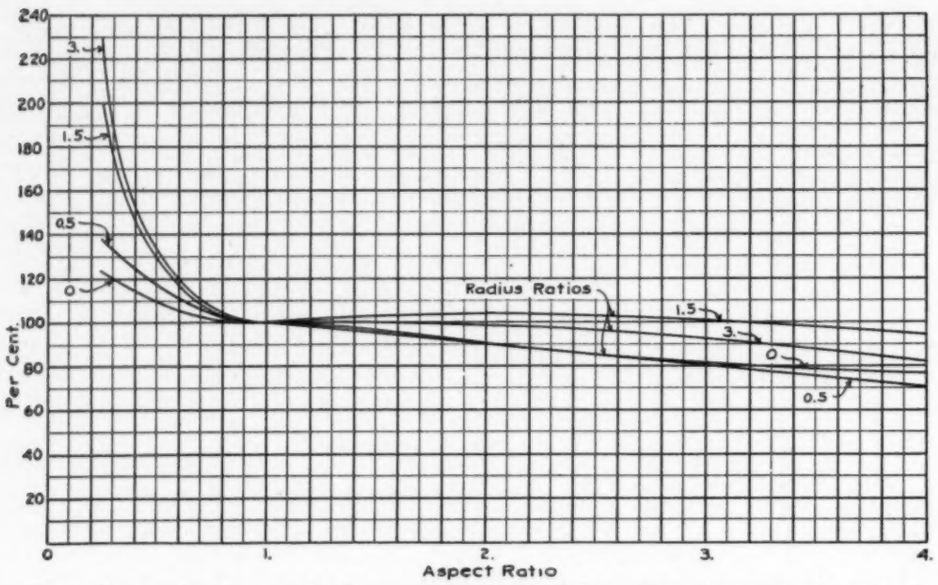

Fig. 6—Pressure loss in per cent of an aspect ratio of unity for radius ratios varying from 0 to 3

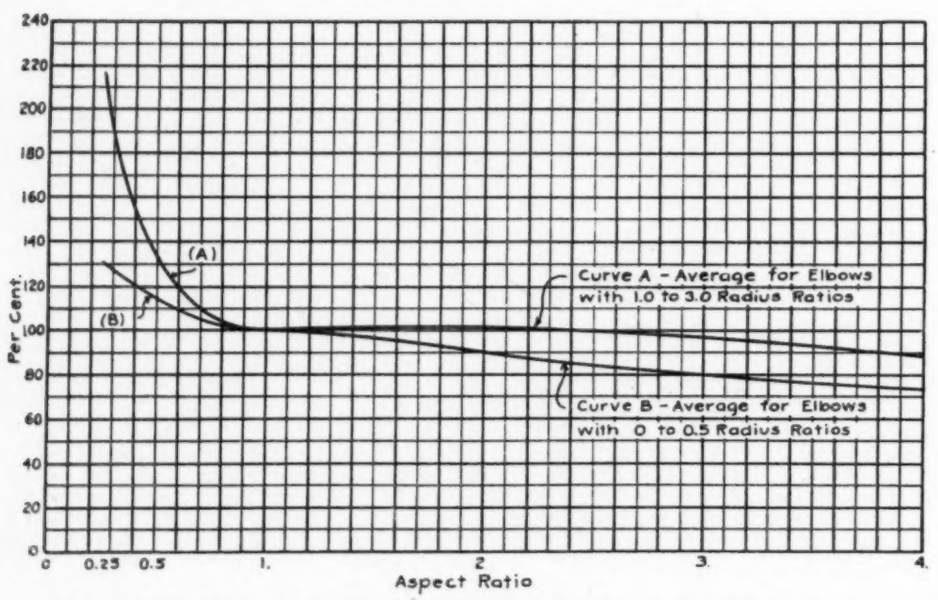

Fig. 7—Pressure loss in per cent of an aspect ratio of unity for average radius ratios

Effect of Velocity

The effect of velocity on pressure loss in elbows depends to some extent upon the relative proportions of

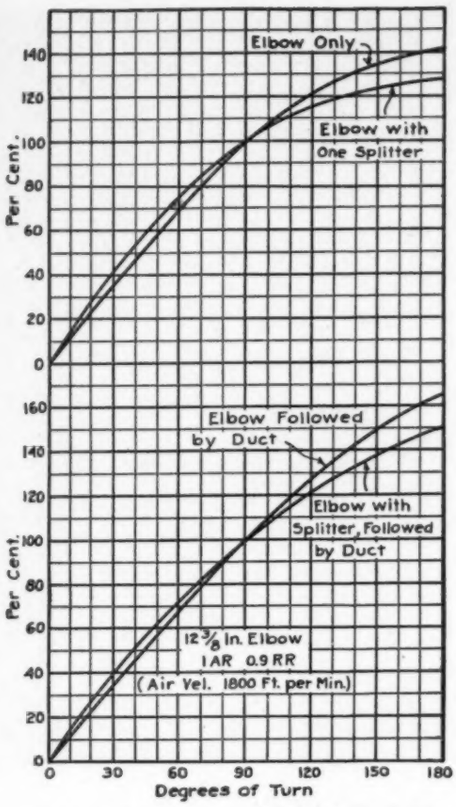

Fig. 8—Effect of only the elbow angle in per cent of the loss for a 90 deg elbow

shock and duct friction losses. In no case is it a large factor for the velocities used in air conditioning work. The range of velocity covered in the tests reported in this paper is from 1800 to 4000 fpm with the majority of the tests being conducted with velocities between 1800 and 2400 fpm. The results of the tests are all plotted on the basis of 1800 fpm.

In order to differentiate between possible variation of loss with kind of elbow, careful tests were run at velocities between 1800 and 3800 fpm on (1) a 3 in. × 12 in. elbow with a radius ratio of 0.5 (zero curve ratio) and an aspect ratio of 4, representing high shock loss, and (2) a 3 in. × 12 in. elbow with a radius ratio of 3 (0.71 curve ratio) and an aspect ratio of 0.25, representing high duct friction. The first elbow showed a pressure loss which varied as $V^{1.92}$ while the second showed a loss which varied as $V^{1.76}$. During tests on a 6 in. × 6 in. straight duct alone the loss varied as $V^{1.81}$.

The effect of uneven distribution of velocity across a duct preceding an elbow has a marked bearing upon the elbow loss. If the velocity is high along the inside radius, or throat side, the loss will be higher than normal, and, conversely, if the velocity is high along the outside, or the side adjacent to the long radius, the loss will be lower. Moreover, if the elbow discharges directly into the air, the variation due to velocity distribution will be more pronounced than if the elbow be followed by a straight section of duct. This principle is of importance

Fig. 10—Elbows of various sizes

in the study of double elbows and helps to explain why 180 deg bends have less loss than two 90 deg elbows. A further application of these data is in estimating the effect of an elbow placed directly on the outlet of a fan. Usually the velocity of air leaving a fan is highest along the outside of the scroll. In such cases, if the throat side of the elbow is adjacent to the scroll, the loss will be high and may be twice the normal value. For side turns away from a fan outlet, the loss usually will be governed by the side of the outlet where the higher velocity occurs. With single inlet, parallel blade fans, the region in which the higher velocity occurs will generally be on the back-plate side of the fan. On the other hand, in conical blade fans or fans with inlet guide vanes, the higher velocity may exist near the center or on the inlet side.

[To be concluded]

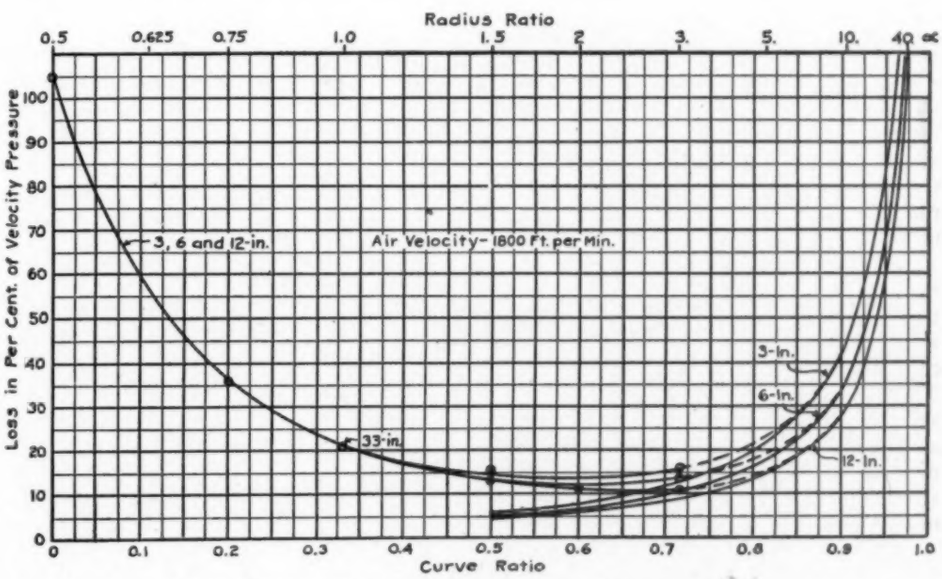

Fig. 9—Effect of the size of 90 deg elbows on the pressure loss

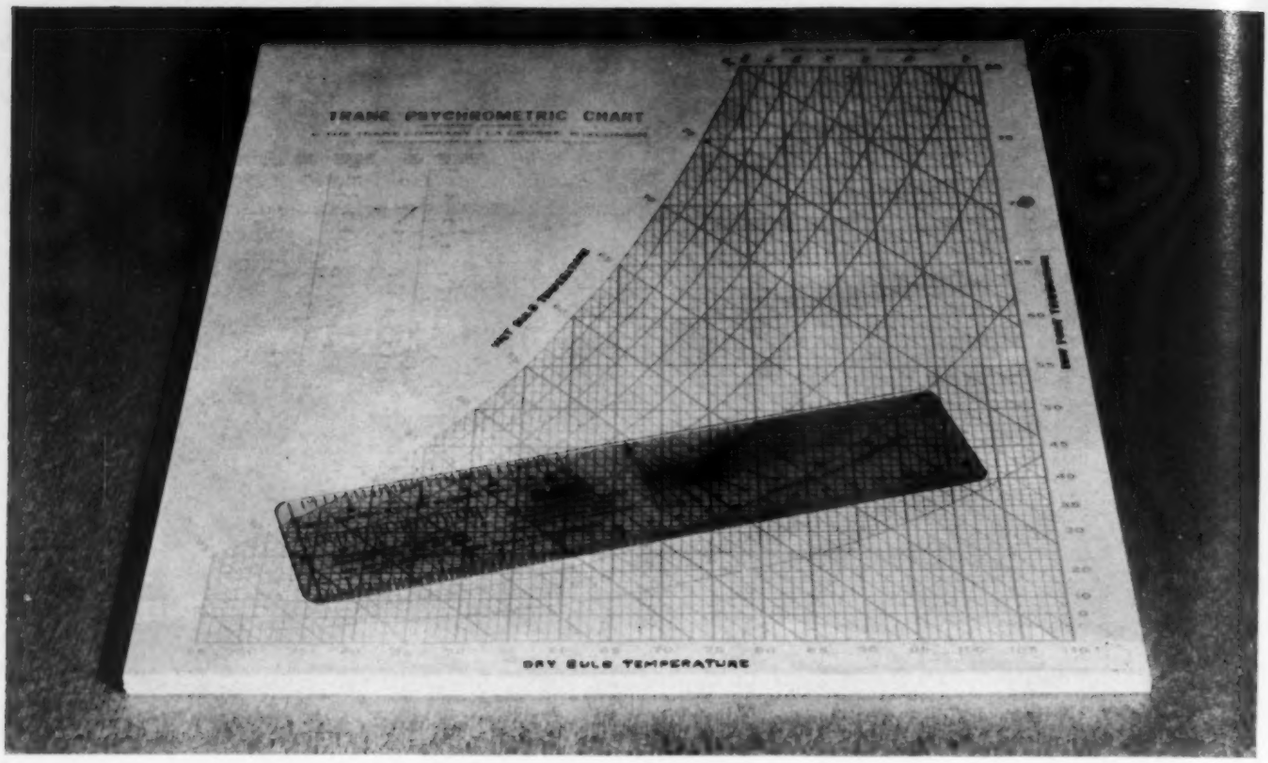

Fig. 1—Air conditioning ruler and "psych" chart, ready for use

Air Conditioning Ruler Aids Use of Psych Chart

By **William Goodman***

EARLIER articles on simplifying air conditioning calculations have described a method of using the author's psychrometric chart together with a protractor and angles corresponding to various sensible heat ratios. A full page reproduction of this chart appeared in the February, 1936, issue, page 88.

In order to facilitate the use of these methods, it was decided to eliminate the necessity of referring to a table of angles for problems whose ratio lines fell in the first and third quadrants of the chart. In doing so, the air conditioning ruler illustrated as Fig. 2 was developed. This ruler, which is made of transparent celluloid, started out primarily as a protractor with the various angles corresponding to the various sensible heat ratios marked directly upon it, but several other uses were soon evolved which were of value in eliminating arithmetical work.

The method of using the ruler is as follows: It is laid on the psychrometric chart with the arrow point of the ruler at the point on the chart representing the desired room condition. The ruler is swung around until the line on it representing the sensible heat percentage[1] of the room coincides with the line of room dew point temperature on the chart. With a pencil the percentage line is drawn on the chart along the upper edge of the ruler, from the arrow to the left. An air supply having any combination of dry bulb, wet bulb and dew point temperatures which intersect on this sensible heat percentage line will maintain the desired room condition.

In addition to the lines of sensible heat percentage, the ruler carries three other scales which are of help in reducing the work of computing the following quantities which must be determined when designing an air conditioning system:

(a) Total heat to be removed in cooling 1 lb of air through any wet bulb temperature range.

(b) Volume of chilled air which must be circulated through the conditioned room.

(c) Weight of moisture condensed from the air.

*The Trane Co., LaCrosse, Wis.

[1]In marking the ruler, the "sensible heat ratio" was called "sensible heat percentage" in order to eliminate decimals. The sensible heat ratio is the proportion of the total heat gain of a room which is sensible heat, the balance being latent heat.

The reception accorded the author's previous contributions to these pages on simplifying the solution of process and comfort air conditioning problems has been so favorable that widespread interest in the subject is indicated. Mr. Goodman describes this month an air conditioning ruler which facilitates further the work of computation of such problems

120,000 Btu per hr to be maintained at 78 F dry bulb with an air supply whose dry bulb is 56 F, and find the volume of air required.

The ruler is laid along any horizontal line of dew point temperature on the psychrometric chart, and is moved along this line to such a position that the arrow coincides with the vertical line representing the room dry bulb temperature of 78 F. The point on the vertical chart line representing the dry bulb of the air supply, 56 F, is located. At this point, the air volume required per 1,000 Btu of sensible heat gain is read on the ruler. The required volume for the conditions of this problem, as read on the ruler, is 41.2 cfm per 1,000 Btu of sensible

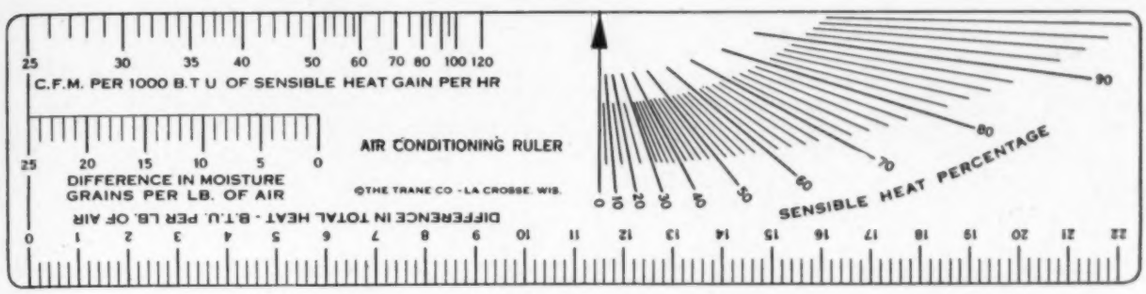
25 30 35 40 50 60 70 80 100 120
C.F.M. PER 1000 B.T U OF SENSIBLE HEAT GAIN PER HR
AIR CONDITIONING RULER
25 20 15 10 5 0
DIFFERENCE IN MOISTURE GRAINS PER LB. OF AIR
©THE TRANE CO - LA CROSSE, WIS.
DIFFERENCE IN TOTAL HEAT - B.T.U. PER LB. OF AIR
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
SENSIBLE HEAT PERCENTAGE
90
80
70
60
50
40
30
20
10
0

Fig. 2—The air conditioning ruler, actual size

Total Heat Removed in Cooling Air

Ordinarily, in computing the total heat to be removed in cooling 1 lb of air through any wet bulb temperature range, it is necessary to refer to a table of total heat content. After finding the total heat content of the air at the initial and final wet bulb temperatures, a subtraction gives the total heat to be removed. The total heat scale of the ruler eliminates both the necessity for referring to a table of total heat content and for subtracting. The total heat to be removed can be measured directly on the chart by means of the Btu scale of the ruler. This is done as follows:

The Btu scale of the ruler is laid on the psychrometric chart in such a position that it crosses all the lines of wet bulb temperature at right angles. To facilitate placing the ruler in position, a line has been drawn completely across one end of it through the zero of the Btu scale. If this zero line is laid directly on the line of wet bulb temperature from which the measurement is to be made, the Btu scale will be in the correct position.

Assume an air supply having an initial wet bulb of 68 F enters a cooling coil where it is cooled to a final wet bulb of 58 F. The zero line of the ruler would be laid on the line of 68 F wet bulb on the chart. At the line of 58 F wet bulb on the chart, 7.05 Btu would be read on the ruler. This is the total heat which must be removed from each pound of air in order to cool it from an initial wet bulb temperature of 68 F to a final wet bulb of 58 F.

Volume of Air to Circulate

The volume of chilled air which should be circulated for any particular set of conditions can be measured on the psychrometric chart by using the cfm scale of the ruler. Assume a room having a sensible heat gain of heat gain. Total air volume required = 41.2 × (120,000 ÷ 1,000) = 4,940 cfm.

Weight of Moisture Condensed

To find the weight of moisture condensed when cooling air through any given dew point temperature range, it is ordinarily necessary to refer to a table giving the moisture content of air of various dew point temperatures. It is then necessary to subtract the final moisture content from the initial moisture content to find the weight condensed per pound of air. Here also the ruler eliminates the necessity for referring to a table and making the subtraction. The weight of moisture condensed from the air can be measured directly on the chart by means of the ruler, as follows:

The grains of moisture scale of the ruler is laid along any vertical chart line of dry bulb temperature. The ruler is moved along this line so that the zero of the scale coincides with the horizontal line on the chart representing the initial dew point temperature of the air supply. At the line on the chart representing the *final* dew point temperature to which the air is cooled, the weight of moisture condensed from each pound of air is read on the "grains" scale of the ruler.

Familiarity with the various scales of the ruler is quickly acquired, and the measurements and computations can be made in a fraction of the time ordinarily required by the use of present day methods. The quickness and ease with which computations can be made by means of the ruler and chart are not the only points in their favor. Since the lines representing the various conditioning processes must be drawn on the chart, the method has the additional merit of providing a graphic and simple picture of the conditioning process. This picture facilitates reasoning in connection with the air conditioning cycle involved.

The reflecting basin at the Texas Centennial, with the Texas Building in the background

Fair Weather . . . . . *By* Charles L. Kribs, Jr.*

DESPITE high temperatures encountered in Texas during the summer, it is possible to be thoroughly comfortable while visiting the Centennial Exposition at Dallas, for air conditioning plays a major role there. On the 200 acre exposition grounds—where buildings housing exhibits of historical interest and depicting the progress of Texas during the past century in agriculture, industry, science, art and transportation are located—there are so many air conditioning installations that it is difficult to pick out the most representative ones. The following paragraphs therefore outline briefly those which are most interesting.

The largest individual exhibit building, that of the Ford Motor Co., is conditioned throughout and utilizes a 400 hp centrifugal refrigerating machine for the main portion and a 40 hp reciprocating compressor for a smaller section. The General Motors exhibit, housed in the Municipal Auditorium which was completely remodelled for the duration of the Centennial, is air conditioned. This system is of interest in that the refrigeration plant consists of eighteen 20 hp condensing units. The Chrysler Building has a 125 ton system.

Fine Arts Museum Conditioned Throughout

The Museum of Fine Arts, a permanent building erected and maintained by the Dallas park board, is conditioned throughout its nine large galleries with year 'round systems. In addition to the comfort angle, adequate conditioning is a necessity in a museum in this part of the country, for the excessive temperatures in unconditioned galleries are detrimental to paintings. This building, without windows or skylights, is accredited with being the only completely artificially lighted museum in the world. The lighting system consists of continuous rows of 100 watt reflectors encircling the walls of each gallery, giving rather high wattages for the room size. Side wall distribution of the air is used and that portion of the supply air which is not recirculated is exhausted through the reflector coves.

The refrigeration equipment comprises three "Freon" compressors with a total capacity of 96 tons served by two evaporative condensers. Direct expansion dry coil units are used in each of the five systems supplying the nine galleries. Pneumatic controls govern the solenoid valves on various coil sections as well as the capacity reducing bypasses on the compressors. Steam coils are provided for winter heating and humidification is accomplished by warm water sprays, all under pneumatic control.

The Museum of Natural History is also a permanent building owned and maintained by the park board. It has no windows and consists of a central lobby from which eight exhibit halls open, four on each floor. The side walls of each exhibit hall are lined with flush cases resembling show windows. The halls themselves are without illumination so that a better view may be obtained of the lighted exhibits. Air conditioning serves all the public areas, and the spaces above and behind the

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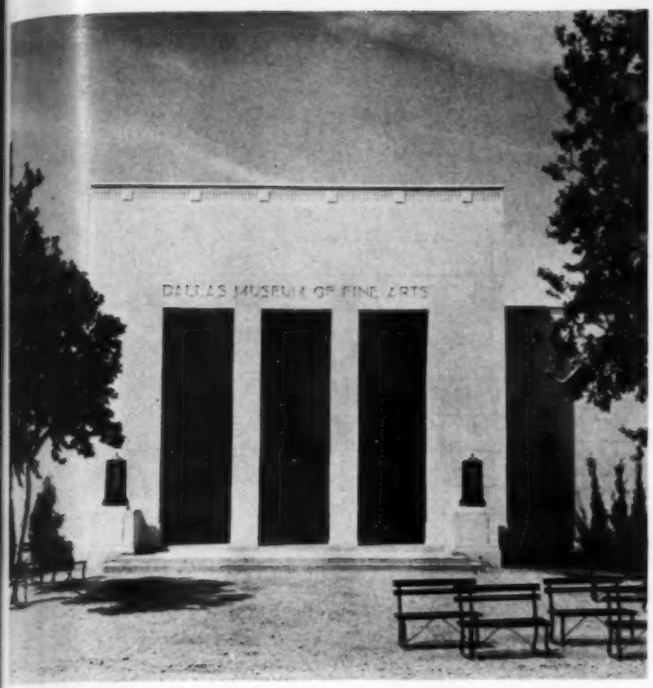

The Museum of Fine Arts, a permanent building, is conditioned throughout with year 'round systems not only for comfort but to protect paintings. This building, without windows, is said to be the only completely artificially lighted museum in the world

Proving itself at Chicago's World's Fair in '33 and '34, air conditioning has become an indispensable service to the modern exposition. At the Texas Centennial, air conditioning not only makes visitors comfortable, but protects paintings and other exhibits as well....The author, whose office was responsible for the design of many of the Centennial systems, the more important ones including the Museum of Fine Arts, Museum of Natural History, State of Texas Building, and the Horticulture Building, here reviews air conditioning at the Centennial.

exhibit cases are exhausted to remove the heat of the lights. Into this space is also exhausted such air from the public areas as is not recirculated. Since the grass, leaves and other background foliage of these exhibits is cast or modelled in wax, temperatures must be kept low enough to avoid softening. The air conditioning equipment includes four "Freon" compressors totaling 85 tons capacity, extended surface conditioning units and pneumatic control. The condenser water is cooled by spraying in a lagoon which is one of the landscaping features of the grounds.

The major axis of the Centennial grounds is established by the main entrance gates and a reflecting basin 1,000 ft long. Centered on this axis and at the far end of the reflecting basin stands the State of Texas Building, the central feature of which is the Great Niche, a semicircular colonnade of native limestone rising 80 ft above the Court of Honor. This building houses four regional halls dedicated to the geographical divisions of the state, an auditorium, the Hall of Heroes and the impressive Great Hall where all state functions are held. The entire building is heated by seven separate blast systems which are designed for air conditioning, though the refrigeration equipment will be a later addition.

Units Heat Greenhouse

The Horticulture Building, another permanent building, houses a variety of Texas plants, trees and flowers. One wing of the building, almost entirely of glass, is filled with tropical vegetation. Hot water heating, long the standard heat for greenhouses, was discarded in favor of a steam system with unit heaters, for the tropical vegetation is very sensitive to cold and rapid heating up is essential to meet the extremely sharp temperature changes encountered in Texas during the winter. Automatic temperature control provides even heating at all times it is required.

The Aquarium, while lacking air conditioning, is of interest due to the water conditions maintained for the different kinds of fish. "Freon" refrigeration reproduces the cold water of mountain streams, water of moderate temperature is provided for the lake inhabitants and warm water for all tropical fish. These three temperatures are maintained summer and winter through a very complete system of thermostatic control.

Gas Engines Drive A. C. Compressors

The Hall of Religion is modern in design, though suggestive of the early Spanish missions. Its interior is divided into a number of rooms, one allotted to each religious denomination. In one wing of the building an auditorium with a pipe organ is provided where services are conducted. The entire structure is air conditioned, using gas as the motive power. Gas engines likewise furnish power for the generation of all current used. The compressor unit is of 40 tons capacity and supplies several direct expansion dry coil conditioners serving the different sections of the building through short duct systems.

A section of the grounds of the Centennial is devoted to model homes of all types of construction. Four of these houses are completely air conditioned. They are furnished with dehumidified air through central duct systems, two of the plants being conventional electric condensing units while the remaining two are powered by small, compact, fully automatic gas engine compressor units installed in sound proof casings. The gas engines are equipped with self-starters of the automotive type and clutches operated by vacuum cylinders which engage the compressor automatically when the engine comes up to operating speed. A multi-point relay makes possible complete control of these systems from an ordinary room thermostat. The normal safety controls also operate the compressor through this relay. One of the gas operated systems is furnished with silica gel dehumidification and separate control is thus had over temperature and humidity.

The Halls of Transportation, Communication, Electricity and Varied Industries—large buildings flanking the central esplanade—are provided with forced ventilation only, but numerous individual exhibits within them have mechanical refrigeration for comfort cooling. Many of the exhibits of the Midway are cooled, and those which are not are mechanically ventilated.

PRACTICAL HEATING

By Harold J. Taylor*

Sizing Steam Coils for Heating Water

In figuring hot water supply systems for domestic service, three important steps are necessary, (1) ascertain what size of hot water storage tank is required to supply the building, (2) figure the amount of heat to keep the water in the tank at the required temperature, and (3) figure the amount of pipe required to give off the necessary amount of Btu's to maintain storage tank water temperature. The accompanying tables are useful for such calculations.

Figuring Apartment Building Job

Example—16 family apartment building. 500 gallon hot water storage tank. Initial temperature of water, 40 F. Water temperature rise in 1 hr, 40 F. Final temperature of water, 160 F. Steam pressure, 2 lb.

Apartment jobs are usually figured on a basis of raising temperature of water 35 to 45 F per hr.

Temperature of steam at 2 lb..... 218.4
Average temperature of water (40 + 160 = 200 ÷ 2).... 100
Temperature difference between steam and water (218.4 — 100) 118.4

To figure Btu's it is necessary to convert gallons of water to lb (1 gal = 8.33 lb) and 1 Btu will raise 1 lb of water 1 F.

To raise the temperature of the water 40 F per hr will require 40 Btu per hr per lb of water.

Since there are 500 gal or 4165 lb of water, 4165 × 40 = 166,600 Btu required.

The next step is to determine the amount of pipe required in the storage tank. At 2 lb steam pressure, the temperature of steam in the pipe coil is 218.4 F and the temperature difference between steam and water is 118.4 F. From Table 3, with a temperature difference of 118.4 F, brass pipe will transmit approximately 32,360 Btu per sq ft per hr, figured as follows:

100 F temperature difference equals 25,000 Btu transmitted.
125 F temperature difference equals 35,000 Btu transmitted.
35,000 minus 25,000 equals 10,000 Btu transmitted.
10,000 divided by 25 equals 400 Btu per degree difference.
400 multiplied by 18.4 equals..... 7360
100 F temperature difference equals.....25,000

Total Btu transmitted per 118.4 F temperature diff.....32,360

Every sq ft of brass pipe surface will transmit 32,360 Btu per hr. Dividing 166,600 Btu by 32,360 Btu, we find that approximately 5.2 sq ft of brass pipe surface is required.

Assume that we wish to use 1½ in. brass pipe for the coil. Since the job requires 5.2 sq ft of heating surface, we refer to Table 2 and find that 2 lineal ft of 1½ in. pipe is equal to 1 sq ft of heating surface. 5.2 × 2 = 10.4 ft of pipe.

In territories where there is a high grain hardness of water due to lime, the use of a steam boiler and steam coil in the storage tank is advisable. With this type of installation the heater does not become plugged up with lime as the same water is used for a long period and only a little fresh water is added from time to time. This is not the case when the conventional hot water supply boiler is used, and all the water used in the domestic hot water supply system is passed through the heater, depositing its lime content. This lime formation in the heater gradually fills up the water passages.

Selecting the Boiler

If we were to select a steam boiler to furnish steam for the coil in the tank in the example we would arrive at the size as follows:

166,600 Btu ÷ 240 Btu (the number of Btu given off by 1 sq ft of cast iron radiation per hr under standard conditions) = 694 sq ft load. Cast iron steam boilers are usually rated in two distinct ratings, such as total output, representing the total output of the boiler at flow outlet, and recommended E. D. R. radiation connected load. In selecting a boiler for radiation heating, the E. D. R. connected load rating is used, but for heating of domestic hot water heating, the total output rating is used.

A steam boiler rated at approximately 694 sq ft, based on total output rating, would be used for our example.

Table 1—Temperature and Pressure of Steam

Steam Gauge Pressure Lb Per Sq In.	Steam Temperature Degrees Fahr
1	215.3
2	218.4
3	221.5
4	224.4
5	227.2
6	229.8
7	232.3
8	234.8
9	237.1
10	239.3

Table 2—Lineal Feet of Pipe per Sq Ft of Surface

Size of Pipe In.	Lineal Ft of Pipe Per Sq Ft of Surface
¾	3.64
1	2.89
1¼	2.3
1½	2.0
2	1.6
2½	1.33
3	1.09
4	0.85

Table 3—"Heating Power" of Brass and Iron Pipe

Temperature Difference, Deg Fahr, Between Steam in Coil and Average Temperature of Water in Tank	Btu Transmitted Per Sq Ft of Pipe Per Hr	
	Iron	Brass
50	4,750	7,400
60	6,500	10,000
70	8,300	13,500
80	11,000	17,000
90	13,000	21,000
100	16,000	25,000
125	22,500	35,000
150	32,000	50,000
175	40,000	62,000
200	52,000	80,000
225	62,000	100,000
250	75,000	120,000

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Alloy Steels for Welded Power Piping

By J. R. Dawson*

THE possibility of improving the thermal efficiency of steam power plants by designing and constructing them for operation at higher temperatures and pressures has long been recognized in theory. Until about six years ago, however, technical considerations limited the practical upper temperature value for superheated steam to 750 F. Modern design and materials have since raised this value to well over 1000 F, and as regards the ability of metallurgists to suggest suitable materials and methods of fabrication for further advances in temperature and pressure, this also seems possible. A more careful study of design and mechanical factors, such as the temperature control of superheated steam, is considered to be the chief preliminary requirement.

The factors involved in choosing piping materials for high temperature and pressure service are discussed, the metallurgical considerations in the welding of alloy steels are given attention, and the properties of low-chromium and higher-chromium steels are outlined, with notes on applications.

Choice of Materials

The choice of materials that will give safe, efficient, and lasting service involves a consideration of their strength, corrosion resistance, and suitability for fabrication. The question of maintaining desirable physical and chemical properties while under stress at elevated temperatures is also important.

Creep Strength—Steam power piping should possess practically all the common strength characteristics, such as tensile strength, impact strength, fatigue resistance, and above all, creep strength. Ordinary mild carbon steel decreases in elasticity above 630 F until at above 900 F it becomes plastic and liable to continue its deformation under stress. Hence, plain carbon steels do not have the creep strength required for satisfactory operation at high temperatures and it is necessary to use alloy steels for such applications.

While the creep strength characteristics of high temperature and pressure equipment are undoubtedly of greatest importance, the designer should not overlook the importance of corrosion and oxidation resistance, both in piping and in valves and other equipment. The efficiency, permanence, and sometimes even the safety of an installation is in a measure dependent on resistance to corrosion.

Corrosion Resistance—The several types of corrosion to which power piping and equipment may be exposed are probably best classified as *external* and *internal*. External corrosion may be caused by the effect of hot furnace gases on superheater or boiler tubes, or simply by the atmosphere acting on the hot metal, especially if steam or vapor is escaping and moisture is present. In this connection consideration should be given to the pipe hangers. The Code for Pressure Piping requires that corrosion resistant metal be used to support piping under conditions causing excessive corrosion. In plants where high sulphur content oils are used as fuel, another type of external corrosion has been observed. The hot combustion gases passing through economizers are cooled to the dew point, and sulphuric acid is condensed.

Internal corrosion of plain carbon steel high temperature equipment is said to be caused not only by the dissolved oxygen and other chemicals entrained in the boiler water, but also by oxygen and hydrogen produced by a slight decomposition of steam occurring at the high temperatures.

Corrosion in the valve parts of steam piping systems is apt to cause sticking, and if it reaches the seating surfaces, their smooth contact is destroyed. Some engineers believe that steam erosion of these valves cannot take place unless a corroded surface is already present. The loosely adherent rust particles can then be carried away by the steam. These particles or scale from the piping may cause pitting and indentation of the seating surfaces, and thus contribute to wire drawing and abrasion. In so far as corrosion is responsible, this may usually be prevented by the proper choice of valve and pipe materials.

Heat Resistance—The various desirable strength characteristics of the materials used, their corrosion resistance, and their structural composition should all be such that they will not deteriorate under operating conditions. Their tendency toward warpage, growth, grain enlargement, and embrittlement should be minimum. In other words, they should be heat resistant.

The relative importance of the requirements cannot be evaluated in general. For some installations a comparatively low cost steel with good fabricating properties might be chosen even though its high temperature strength were only nominal, while in another installation the steel with the greatest strength or resistance to oxidation, as the case may be, might be the proper choice even though its cost were several times as great. As the operating temperatures approach and exceed 900 F, carbon steels become less satisfactory and the service requirements can be met only by carefully chosen alloy steels.

The Welding of Alloy Steels

The welding procedure should be adapted to the material and design. For example, certain alloy steels are apparently well suited for use at high temperatures and pressures, but their composition must be modified for welding if they are to retain their fine grain size, their ductility, or their corrosion resistance. With certain

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From a paper presented at the Midwest Power Engineering Conference.

types of chromium-containing steels, the inclusion in the analysis of nitrogen or of columbium, or the reduction of the carbon content, may be all that is required.

In regard to design, such factors as suitable provision for expansion, adequate anchorage for pipes, and the use of gradual curves, are often fully as important to the success of a welded installation as the welding rod itself. Valves should be designed for welding.

Adapting the welding procedure to the design and material involves such considerations as manipulative techniques, choice of welding rod, stress relieving, blowpipe annealing, care in cooling, and general procedure control. Some of these can only be mentioned here because the field is too wide for a comprehensive discussion.

Alloys Most Useful in Steel

The alloys found most useful in steel suitable for high temperature, high pressure steam equipment are chromium, molybdenum, tungsten, nickel, vanadium, manganese, and silicon. Experimental work with columbium, titanium, and nitrogen indicates that chromium steels containing these elements will find extensive use in high temperature, high pressure equipment.

Each of these elements exerts very definite influences on the steel to which it is added, but the effect of each is modified by the presence of other elements and by the amount of carbon. It thus becomes of the greatest importance to obtain a proper relation between the amounts of the alloying elements in order to secure the best results. Alloy steels in which the proportions of the various elements have been chosen so as to give the best possible combination of the required physical and chemical properties are sometimes called balanced alloy steels. Frequently one type of balanced steel can be further benefited by the use of one or more additional elements. This is, at least in part, an explanation of why some of the more or less complex alloy steels have been developed.

Low-Chromium Steels—Practically all steels designed to be used at high temperatures contain chromium. The general effect of chromium is to increase strength, hardness, oxidation and corrosion resistance, and creep strength. Even in amounts less than 1 per cent, chromium tends definitely to improve oxidation resistance and creep strength. Balanced with manganese and silicon its ultimate strength and creep strength are both good in contrast to plain carbon steel. Steels containing 0.4 to 0.6 percent chromium, 1.1 to 1.4 per cent manganese, and 0.6 to 0.9 per cent silicon, have a creep strength approximately 50 per cent higher than that of carbon steel at a temperature of 1,000 F. The use of vanadium, molybdenum, or nickel also improves the creep strength of low chromium steels. A 0.62 per cent chromium steel with 0.95 per cent manganese, 0.20 per cent silicon, and 0.20 per cent molybdenum also has a good creep strength at moderately high temperatures.

Turbine parts giving good service at high temperatures contain the following alloy percentages: 0.30 carbon, 3.1 nickel, 0.35 chromium and 0.35 molybdenum. Exceptions are parts which must be especially resistant to erosion, such as the 14 per cent chromium nozzle sections and the high nickel chromium first wheel blading.

A number of molybdenum-containing steels have been used at moderately high temperatures on account of their high creep strength, but unless chromium is present, they have no special corrosion resistant properties.

One plant finding it desirable to use chromium molybdenum and chromium nickel tubing in radiant superheaters and reheaters operates at temperatures as low as 800 to 830 F. In this case there are several thousand square feet of projected tube area, and it would not be good policy to use plain carbon steel and risk losing it through long time corrosion. As the pressure is 1,230 lb per sq in., strength is also a factor.

Higher-Chromium Steels — For higher temperatures, creep and corrosion considerations demand greater percentages of chromium. A 1 to 1.5 per cent chromium steel with about 0.5 per cent molybdenum and 1 per cent silicon compares in creep strength with the well-known high alloy 18 per cent chromium, 8 per cent nickel steel at 1,000 F; but its oxidation resistance is not particularly high.

Probably no relatively low alloy steel can be more highly recommended for general use in high temperature steam applications than a 4 to 6 per cent chromium steel containing molybdenum or tungsten. Having been used successfully in the oil cracking industry, this steel should prove excellent for superheater tubes. Its creep strength is approximately double that of plain carbon steel at a temperature of 1,000 F, and its resistance to scaling and corrosion is much greater than that of plain carbon steel at temperatures up to at least 1,200 F.

A valve body made of this alloy with 1 per cent tungsten showed no embrittlement after 13,000 hr service in a 1,000 deg plant. The addition of titanium or columbium to this metal will no doubt greatly increase its field of usefulness, because it entirely eliminates the air-hardening characteristics of this steel, and at the same time improves its resistance to corrosion.

Intermediate between the 18-8 chromium nickel steel and the 5 per cent chromium steel, in regard to oxidation and corrosion resistance and creep strength, a 9 per cent chromium steel containing 1.25 to 1.75 per cent molybdenum has recently been announced as suitable for service temperatures up to 1,250 F. Seamless tubes of this metal are now in service in many oil refineries, and should be suitable for superheater tubes in steam boilers.

The 17 to 20 per cent chromium and 7 to 10 per cent nickel low carbon austenitic steels probably have the best combination of properties now available in commercial steels for the several high pressure, high temperature service conditions. Columbium or titanium is add to prevent embrittlement and corrosive action at temperatures up to 1,500 F. Tungsten and silicon give it a very high creep strength, and its corrosion and oxidation resistance is such that it will resist scaling indefinitely at a temperature as high as 1,700 F. Although piping made of this type of steel has given entirely satisfactory service in high pressure applications at 1,100 F, still the 5 and perhaps the 9 per cent chromium alloys will probably be more generally used for some time to come on account of their relatively low cost.

Metallurgical Considerations in Welding

It might be well to conclude with a brief mention of some of the metallurgical considerations involved in oxy-acetylene welding these metals. Inasmuch as low chromium steels have a slight tendency to lose their ductility when too rapidly heated and cooled, the backhand welding method is recommended by the author because of the gradual heating and the fact that the backward streaming gases retard cooling. For welding pipe walls less than ¼ in. thick, a plain steel welding rod often can be used as it will receive a sufficient quantity of alloys from the melted base metal. For more severe service, it is frequently advisable to choose the 18 per cent chromium, 8 per cent nickel steel welding rods.

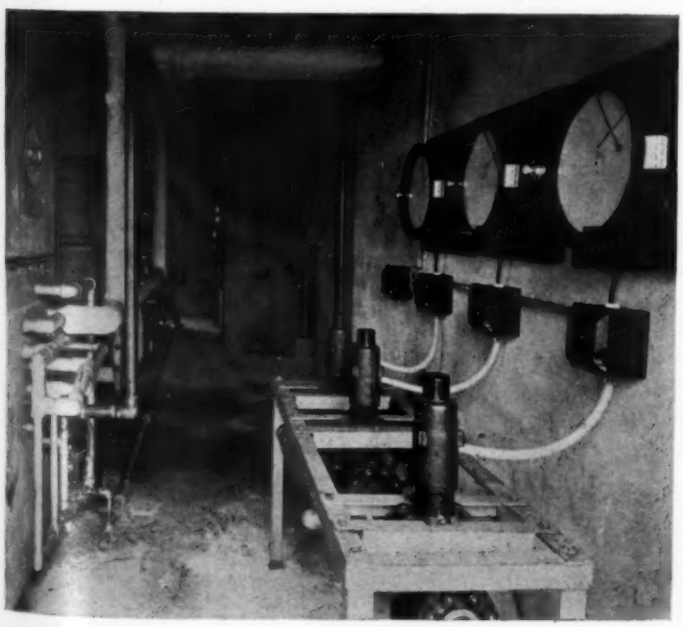
In welding the 1 per cent chromium steels the same general considerations apply as in welding the 5 per cent or the 9 per cent alloys. The main consideration is a tendency toward brittleness in the weld metal exhibited in the higher carbon steels. This can be alleviated by annealing for about 3 min. at 1,200 to 1,400 F. If carefully done, the flame can be used for applying the annealing heat. Columbium or titanium used in the steel preserves the ductility and eliminates the need for subsequent annealing.

Columbium is also the key metal in the successful welding of the 18 per cent chromium, 8 per cent nickel type of austenitic steels. Previous to the use of columbium in the welding rod and of columbium or titanium in the base metal, the regions adjacent to the weld were sometimes observed to have lost some of their resistance to corrosion. Annealing at about 1,800 F was found to restore this resistance, but this is not always practicable in the field. Various expedients, such as rapidly cooling the weld and reducing the carbon content of the steel, have been found helpful; but none are so satisfactory as the use of columbium.

Building Meters Air Conditioning Service

By **Paul E. Holcombe***

AT the Lincoln Theater Building, Miami Beach, Florida, the liquid refrigerant is metered so that air conditioning operating costs may be properly allocated between the principal individual tenant, the 1,300 seat Lincoln Theater, and the rest of the load—offices, a drug store, and specialty shops. As when steam or electricity is metered instead of being paid for at a flat rate, the scheme employed insures that the tenant pays for the service that he actually uses.



The master liquid meter and the two sub-meters which, by measuring the liquid refrigerant, permit the proper allocation of air conditioning operating cost to tenants of the Lincoln Theater Building

It is believed that this is the first time liquid refrigerant has been successfully metered and sold on a unit basis—in this case, at a price per pound. Three liquid meters are used, one as a master, one a sub-meter measuring the refrigerant used by the theater, and the other for the balance of the building. A constant check is thus provided by comparing the sum of the two sub-meter readings with the master meter reading. Accuracy is maintained by sub-cooling of the refrigerant.

Three 40-ton "Freon" compressors are used, each having a suction bypass control, and all equalized. Evaporative condensers remove the heat from the refrigerant, with the compressors so controlled automatically that under certain favorable circumstances, air cooling of the compressors is used. When the compressors are operating air-cooled, it becomes the largest air-cooled installation known. Belcher Industries, Inc., installed the system.

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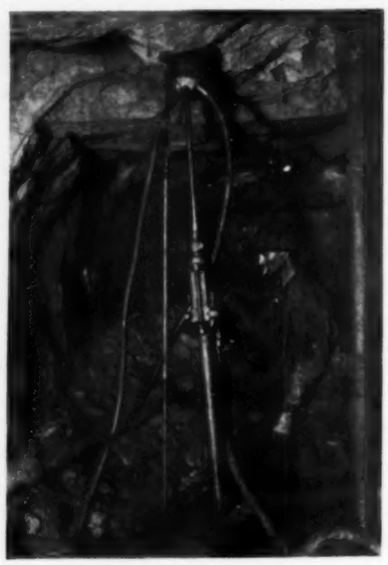
National Silicosis Conference Outlines Objectives

THE National Silicosis Conference, which recently convened in Washington, D. C., at the invitation of Secretary of Labor Frances Perkins, was comprised of some 200 representatives of industrial, labor, medical, engineering, insurance and administrative groups, perhaps the largest and most representative body ever called together on this subject in the United States.

Secretary Perkins explained the interests of the Department of Labor in silicosis, pointing out that it was sponsoring the conference pursuant to the authority granted in its organic act to "improve industrial and working conditions and to create favorable opportunities for employment for the wage earners." She said there is on hand much knowledge of silicosis, which, evaluated and translated into definite programs of action, will go far toward controlling this industrial disease.

"The technique of silicosis prevention lies," she said, "in keeping the dust from getting into the air which the workers must breathe. This can be done by different types of ventilation, including specialized control and collection of the dust at the point of origin so that it does not escape into the workroom." Among the other effective methods of control cited by Secretary Perkins were employment of wetting down processes, good housekeeping, and the use of positive pressure masks. The latter means, she declared, is satisfactory only for short periods of exposure.



Rock drilling with dust collecting device in operation

● *By* **R. Campbell Starr*** ●

Speaking on "Silicosis as an Employer Problem," A C. Hirth, of the Air Hygiene Foundation, said that "A consideration of the many aspects of the silicosis problem clearly indicates that the interests therein of employees, employers, and the public proceed along parallel lines. The employers of the country can be counted upon to cooperate wholeheartedly with the Department of Labor, with the Public Health Service, with other pertinent public authorities, and with labor itself, to reach the solution of this problem along sane, constructive, and effective lines."

John P. Frey, president of the metal trades department of the American Federation of Labor, acting as spokesman for organized labor, pointed out the worker's need for adequate compensation insurance coverage for silicosis until such a time as prevention of the disease is an accomplished fact. "The purpose of this conference," Mr. Frey said, "is to consider ways and means of its (silicosis) elimination, fully as much as to determine what compensation should be given to the infected and afflicted workmen. Labor is primarily interested in having the cause removed, but is compelled in the meantime to actively engage itself in an effort to secure adequate compensation for the afflicted and their families. Labor is particularly interested in prevention, rather than compensation, for labor is convinced that once the danger of silica dust in industry has been eliminated, there will be no silicosis for which compensation is required." He, too, stressed the need for cooperative action of all interests in order to carry out the conference's work.

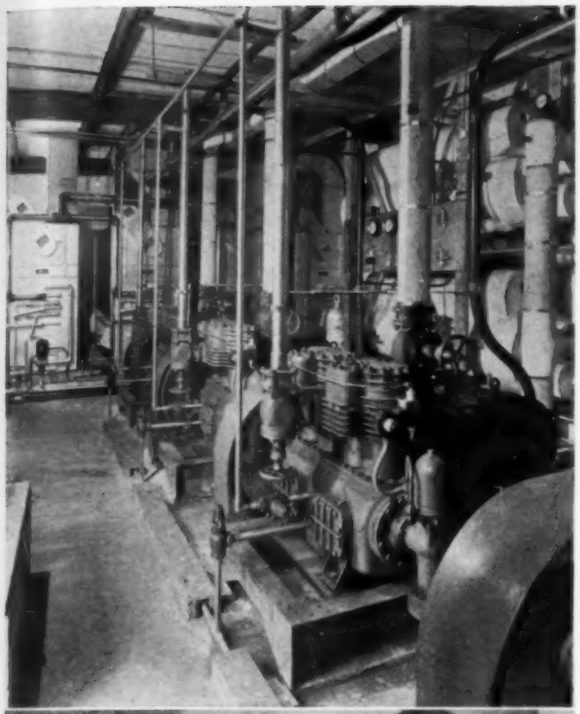
Dr. R. R. Sayers, Senior Surgeon, U. S. Public Health Service, discussed at some length the medical aspects of silicosis and means of control. He described the disease and the chief causative factors, stressing the preventive phases, both from the medical and the engineering point of view, and emphasizing the need for close cooperation between medical and engineering personnel for economical and safe control of the dust hazard.

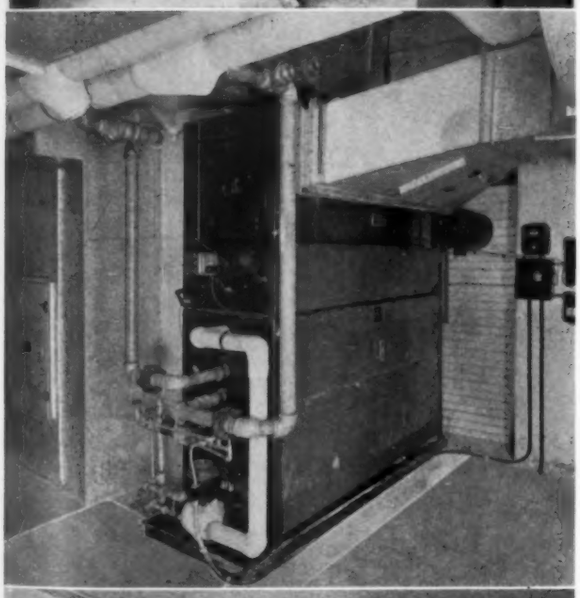
Immediately following the meeting, Secretary Perkins announced the appointment of four committees composed of experts in their respective fields to undertake detailed study on the technical phases of the problem: (1) Prevention of Silicosis Through Medical Control. (2) Prevention of Silicosis Through Engineering Control. (3) Economic, Legal and Insurance Phases. (4) Regulatory and Administrative Phases.

These committees, which have already begun their analysis of the problem, are expected to complete their work during the fall or early winter. It is hoped that, as a result of their research, including an evaluation of the present statuts of medical and engineering control measures, certain broad recommendations can be made which are susceptible of immediate translation into preventive action by every industry confronted with a silicosis hazard. It is also hoped that the group studying the economic, legal and insurance problems resulting from silicosis, as well as the regulatory and administrative committee, will be able to evolve a practical and effective set of principles which can be equitably and promptly applied by the several States to provide proper compensation for disabled silicotic workers until such a time as the disease, through adequate medical and engineering control measures, has been effectively controlled or entirely eliminated.

The committee reports will be presented to another large national gathering, to which will be invited representatives of every group having an interest in the solution of the silicosis problem. It is likely that this conference will be called early in December, for consideration and possible adoption of the committee recommendations.

*Executive Secretary, National Silicosis Conference.





Two years ago the Carlton Hotel, Washington, D. C., tried out bedroom air conditioning with an installation on the eighth floor, found that "air conditioning is demanded in downtown Washington," consequently ordered an installation to serve every one of its bedrooms, the main dining room, cocktail lounge, ballroom, grill room, and patio. . . . The design of the system permits the flexibility of operation required by a hotel, and the method of control allows matching compressor operation to the load.

Carlton Hotel Air Conditions

By T. D. Carson*

ON July 4, 1936, the Carlton Hotel, Washington, D. C., declared its independence of the vagaries of the weather, for on that date the system for air conditioning all bedroom floors, the main dining room and cocktail lounge, the ballroom, grill room and patio began full operation. The Carlton is one of the first hotels in the world to install air conditioning for bedrooms, as two years ago several rooms on the 8th floor were conditioned; in fact, Washington Properties, Inc., the owners and operators, have pioneered in another way, being the first—excluding the government—completely to air condition an office building in Washington.

At the time the Carlton's 8th floor installation was made, it was thought that eventually it would be extended throughout the building. While this system has not been changed, the main chilled water piping is so arranged that if it is desired in the future to remove the 8th floor refrigerating machines and connect the system to the new refrigerating plant, it will be possible.

The new installation consists essentially of:

(1) A refrigerating plant situated in a small building adjacent to the hotel. In this building are four "Freon" compressors, each driven by a 40 hp motor

***Top to bottom*—Compressors, pumps and evaporative condensers are in a small building adjacent to the hotel, chilled water being circulated from this plant to the air conditioning units serving the bedrooms, dining room and other spaces. . . . This unit serves the dining room and cocktail lounge. . . Typical bedroom, showing the grille over the door**

*President, Washington Properties, Inc., Washington, D. C.

and with a total capacity of approximately 180 tons, four evaporative type condensers, each handling 8,000 cfm and each with a 3 hp fan motor and 1/6 hp pump motor, and two shell and tube coolers, together with two pumps circulating 500 gpm, one driven by a 15 hp motor and the other by a 7½ hp motor. This plant cools water which is then pumped through cooling coils on four sets of dehumidifier units serving the conditioned spaces. This chilled water is pumped through a closed circuit.

Four Fans Supply Bedrooms

(2) The bedroom floors are served by two closed circuit type dehumidifiers and four fans situated in two different rooms on the 4th floor. The dehumidifiers are complete with coils, tank, eliminators, spray pump and auxiliaries, and each has a ½ hp pump motor. The four multiblade, full housed centrifugal fans are each driven by a 3 hp motor and are set on isolating bases with fire-resisting cloth connections to inlet and discharge ducts. From the two fan rooms, ducts lead to the bedroom floors. Large supply ducts are suspended from the corridor ceilings with branch ducts leading into each bedroom. Air is brought back through the corridors to return ducts at two points on each of the floors.

Supplying these bedrooms with four fans gives a flexibility of hotel operation which is desirable, as certain rooms or whole floors may be removed from service without affecting the remainder of the system, except to reduce the load on the refrigeration plant. Two of the fans supply the 2nd, 3rd, and 4th floors and the other two supply the 5th, 6th, and 7th floors. By running one or more of these fans it is possible to condition either part or all of the areas served. Total number of bedrooms is 256.

(3) The main dining room, approximately 68x38x17 ft, and cocktail lounge, 30x30x17 ft, are served from a separate air conditioning unit in the basement, which unit is complete with fans, coils, pump, sprays, etc., all mounted in one casing and equipped with a 3 hp fan motor. Air is distributed by a series of ducts with openings at various points in the rooms.

(4) A fourth air conditioning unit, identical with that used for the dining room, takes care of the ballroom, grill room and patio.

Approximate sizes of these rooms are, respectively, 70x36x17, 70x32x12, and 45x45x17 ft.

The refrigeration plant furnishes cold water for all four sets of conditioning equipment and has sufficient capacity to cool the top floor now serviced by a separate plant.

As the supply ducts for the bedrooms run down the corridors a false ceiling was erected below all of the ducts so that none is exposed to view. Likewise, the ducts serving the other portions of the building are furred in, with the exception of those which run through the service portions of the basement. Outlets of the latest type which make it possible to adjust either the vertical or horizontal flow of air and produce an even distribution over the area being served are used throughout.

Precautions were taken to eliminate noise from the conditioned areas. Sound absorbers were installed in the supply and return air ducts. In the case of the two fan rooms on the 4th floor which supply air to the bedrooms, all of the fan room walls and ceilings are covered with a sound absorbing material.

Control Permits Operating Flexibility

There are certain automatic control features of this installation which are worthy of mention. The four compressors are so connected that one, two, three or four will automatically be in operation according to the load on the plant at any one time. Also, as the load decreases with a drop in outside temperature or a reduction in the amount of space being served by the plant, these machines will automatically shut down, thus insuring against the possibility of running more equipment than is required to carry the load. Adjustment of the number of machines in operation to correspond to the load is accomplished in general as follows:

There is an electric thermostat in the chilled water line returning from the air conditioning equipment to the refrigeration plant. As the temperature of this water tends to rise, this thermostat changes the resistance on one side of a circuit corresponding to one side of a Wheatstone bridge. On the other side of this Wheatstone bridge the balancing resistance is connected to a small motor rotating a cam shaft. As this shaft rotates the four cams mounted on it make contact for starting the different compressors.

Thus, as the thermostat in the water line is affected by change in temperature, it in turn, through the above mechanism, controls the position of the cam shaft, which in turn controls the number of compressor motors in operation. A slight rise in the temperature of the water returning from the cooling coils (indicating an increased load) is sufficient to start additional equipment.

Temperatures and humidities are automatically maintained at all times. The present installation, while designed principally for cooling, can also be used for heating by disconnecting the compressors and connecting the water lines to hot water storage tanks, so that hot water instead of cold water will be pumped through the coils of the four conditioning units.

"Through these portals pass the most famous people in America"—to air conditioned comfort. Washington's Carlton Hotel appropriately declared its independence of the weather on July 4, when its new air conditioning system was placed in service

Hotels Find Air Conditioned Bedrooms Pay

THE hotel bedroom has been given major air conditioning attention in recent months, following experience of guests' reactions to a number of trial installations; application of air conditioning to this service has been stimulated by the large number of air conditioned railway cars now in service, as a traveler, comfortable on the train, wants the same comfort at his hotel. Some of the high-lights of this development:

■ St. Louis' STATLER, whose new installation air conditions all lower sections of the hotel as well as 300 bedrooms. According to President Frank A. McKowne of the Hotels Statler Co., air conditioning will soon cease to be a luxury, will be a necessity in the better class of hotels. A feature of the installation is that guests may control the extent of cooling and air circulation in their rooms. The room units are served by cold water from a central plant. . . During the recent heat wave, guests wouldn't budge from their air conditioned rooms, called room service for their meals. Salesmen stopping at the Statler phoned their customers; invited them over to the Statler where business could be done in comfort. House count tripled, room service force had to be doubled.

■ Washington, D. C.'s HARRINGTON, which air conditioned 240 rooms last fall, at a cost per room of less than $150, estimated operating cost per room for a four month's season being $4, not including interest or depreciation; well water is used. Business has increased, the Harrington's reputation for progressiveness has been maintained; because guests like the freedom from street noise with windows closed, the Harrington has decided to furnish tempered ventilation the year around. The management concludes no mistake was made in wholesale air conditioning of bedrooms, plans to extend the system. During the recent hot spell, several Washington residents left their homes, moved into the Harrington—a new source of business for the air conditioned hotel.

■ Chicago's STEVENS offered a new idea in hotel service with the opening of its "de luxe" 23rd floor last month, where suites air conditioned with self-contained units are available at an additional charge of $1. Air conditioning is regarded by Manager Eitel as the last luxury touch for suites of this kind, will be installed for other guest rooms if the public favor expected is received.

■ Chicago's PALMER HOUSE recently installed air conditioning for several bedrooms.

■ San Antonio's ST. ANTHONY, completely air conditioned last year with a large central system serving dining rooms, offices, shops and 450 bedrooms. Experience with the system has convinced the management of the value of guest room air conditioning.

■ Washington, D. C.'s CARLTON tried out bedroom air conditioning two years ago, has just put its complete air conditioning system in operation, for it found that air conditioning is demanded in downtown Washington.

■ Seymour Weiss, managing director of New Orleans' ROOSEVELT, found that air conditioned bedrooms met the approval of every patron, believes that ultimately all hotels will be air conditioned, particularly in the south.

■ Manager Heidelberg of Baton Rouge's HEIDELBERG is convinced that all modern hotels are coming to air conditioning, bases his opinion on the comments of the traveling public. First five floors are air conditioned, including 100 bedrooms.

■ Manager Shroyer of Wichita Falls' KEMP felt that, when it was decided to modernize the Kemp, air conditioning seemed without a doubt to be the innovation best suited to the hotel business, was farther reaching than any of the other improvements contemplated. Following the initial installation for 150 rooms, 50 more rooms were conditioned, as the house count, room occupancy and cash receipts during the summer months—formerly the quietest business months of the year—fully justified the expenditure for air conditioning.

■ The PLAZA HOTELS, San Antonio and Corpus Christi, surveyed guests' reactions to air conditioned rooms, found that 71.9 per cent would prefer an air conditioned room, 67.1 per cent would be willing to pay extra for it.

■ The HOTEL MAYTAG, Newton, Iowa, found that air conditioned bedrooms increased business, cut cleaning costs in half. Patrons drive through larger towns, stop at Newton (Pop. 12,000) because of air conditioning, stay longer at the Maytag.

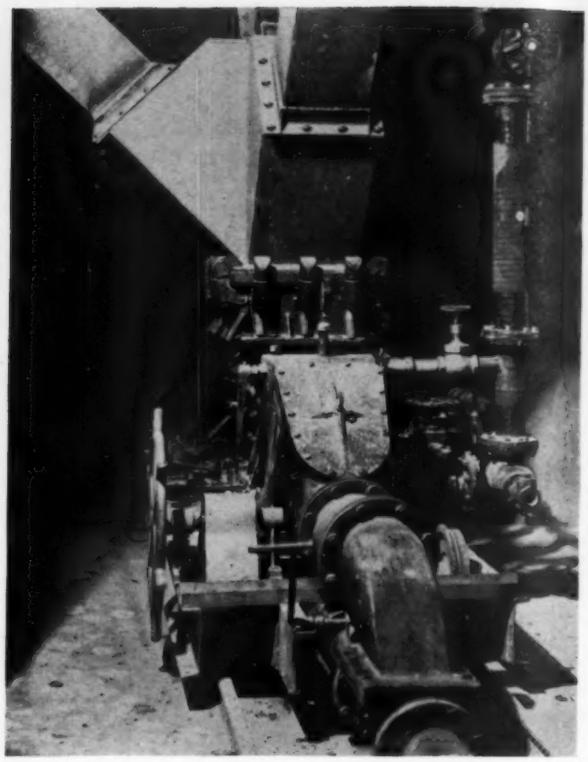
■ According to Ralph Hitz, President, National Hotel Management Co., hotel operators have been called upon to provide the finest that money can buy ever since the first innkeeper went into business. Air conditioning is unquestionably one of the outstanding contributions to living comfort, he believes. An installation for one of the guest suites at the HOTEL LEXINGTON, New York, met with instantaneous success, and the suite became the most popular in the house.

■ The DEARBORN INN, Dearborn, Mich.—pioneering in complete hotel air conditioning and with 100 air conditioned bedrooms—asks guests how they like air conditioning, finds the answer always in the affirmative. Most favorable comment usually comes from traveling men "Best night's sleep I've had this summer."

High-Lights in Development of New Service

Industry's greatest transportation system, piping, plays an essential part in a wide variety of manufacturing processes. Briefly described here is the plant of the National Portland Cement Co. and the piping for conveying slurry and cement

By . . . . **Ralph H. Butz**



One of the pumps which run on tracks under the silos

Piping Slurry and Cement at a Modern Mill

THE installation of piping systems for transport of slurry and finished cement at the new plant of the National Portland Cement Co., Brodhead, Pa. was recently completed. The piping and the methods by which slurry and cement are conveyed through the system are of particular interest as they represent modern practice in material transport in a cement mill.

When the rock is brought from the quarry to the grinders, about 35 per cent of water is added to it as it goes into the tube mills. The ground rock and water which is discharged from the tube mills is known as slurry. This is delivered to a slurry sump which serves two centrifugal slurry pumps. The two pumps discharge their contents to a common 8 in. diameter pipe line which delivers the slurry to the slurry silos. Lubricated plug valves are used on both the suction and delivery pipe lines.

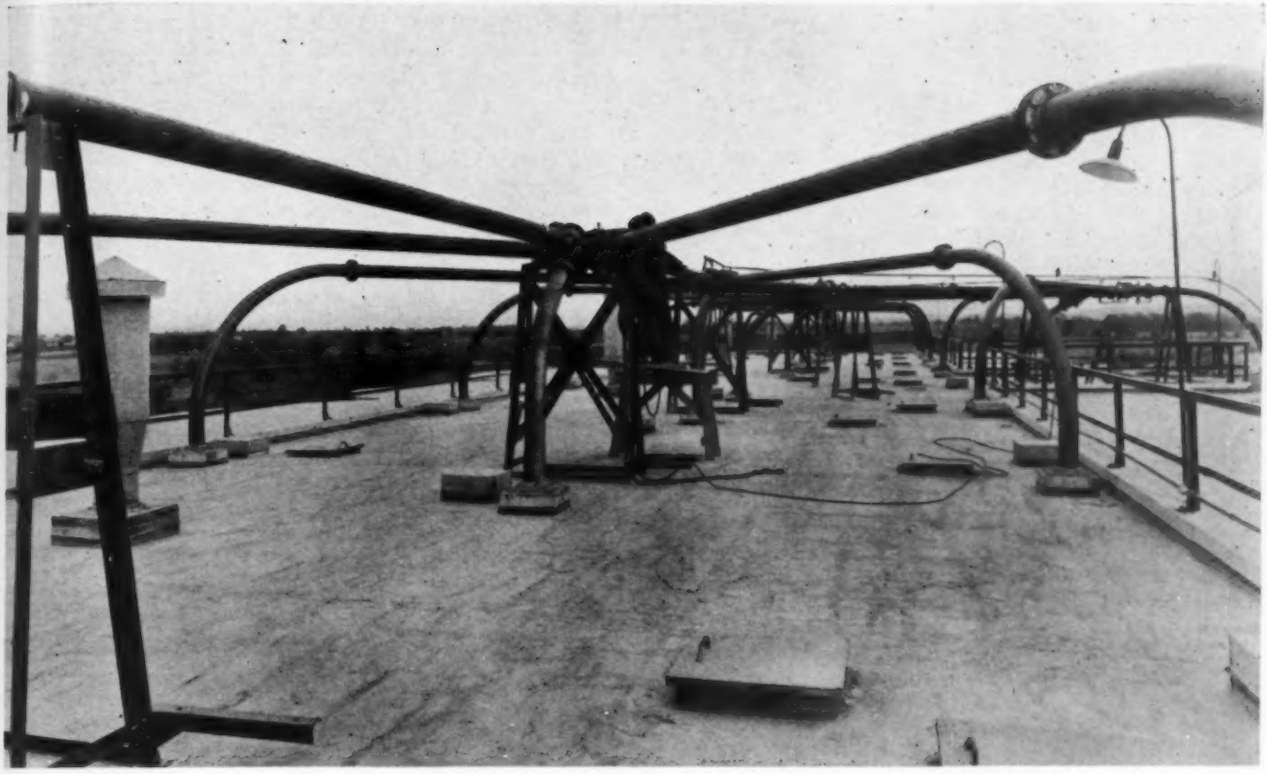
There are six slurry silos, each 22 ft in diameter and 40 ft high, with conical bottoms. These silos are provided with air agitation, the compressed air entering the silos through the conical bottoms.

The six silos are arranged in two rows, three silos in a row. The bottoms of the silos are connected by means of duplicate sets of piping. One system leads to a slurry sump ahead of a 6 in. pump driven by a 100 hp motor. If the slurry in any silo has to be blended with that in another silo, the requisite amount of slurry is drawn off from each and delivered to the slurry sump. This slurry is then pumped to a third silo.

The slurry basin is a rectangular concrete tank 200 ft long, 35 ft wide and 21 ft deep, holding slurry sufficient for manufacturing about 15,000 barrels of cement. The slurry in the basin is kept in an intimately mixed state by means of a traveling mechanical agitator mounted on a bridge which moves back and forth on tracks laid on the walls of the basin. The agitator makes a round trip in about 15 minutes.

The slurry pumps for handling the slurry leaving the basin are in a pump pit at one end of the basin. There are three 3 in. pumps for delivering the slurry to the kilns, two being ample for the kiln requirements and the third serving as a stand-by unit. Each pump is coupled direct to a 40 hp motor. All pumps are interconnected to duplicate 6 in. slurry pipe lines which deliver the slurry to the feeders over the kilns.

As an additional safeguard, the recirculating slurry pump installed in connection with the slurry recirculating system can also be connected to deliver slurry direct from the silos to the kiln feeders. Excess slurry pumped to the slurry feeders returns by gravity to the basin.



Piping on top of the cement storage silos

The slurry passing through the kiln emerges in the form of clinkers which then pass to the finishing mill, where they are ground into finished cement. This cement is transported from the finishing mill to the cement storage silos. The pneumatic pumping equipment for this service is directly below the cement storage bin into which the cement is delivered from the tube mills and separating units. It consists of a battery of two cylinders, each about 6½ ft in diameter. The tops of these cylinders are connected to the cement storage bin by means of a horizontal feeding device. A cut-off valve is placed between each cylinder and its feeder.

Compressed air is the medium for moving cement from the cylinders to the storage silos. The cylinders operate on two cycles, one the filling and the other the blowing cycle. When one cylinder is being filled with its charge of cement, the cement in the other cylinder is being blown out by compressed air under a pressure of about 30 lb per sq in.

High and low level indicators control a pilot valve which controls the supply of air and cement to the respective cylinders. The cylinders accordingly fill and empty at regular intervals. The discharge output of each cylinder is connected to a 6 in. pipe line which transports the cement to the silos. Valved branch piping over the silos enables cement to be delivered to any of the 25 silos.

Each silo is 25 ft in diameter, 75 ft high, and has a capacity of 10,000 barrels of cement. A basement 13 ft high is provided under the entire block of silos. In this basement three 7 in. pumps, mounted on trucks, run on tracks to connect with each silo. These pumps transport the cement through 6 in. pipe lines from the silos to the packing house.

The cement transport pipe lines are so arranged that the cement may be transported either direct to the packing bins or else delivered from one silo to another.

The cement enters the packing house at the third or top floor through three 6 in. lines, so arranged that they will deliver cement to any of the four bins, each of which has a capacity of 400 barrels.

From these overhead storage bins the cement is delivered to the inlet hopper of the packing machine by means of a horizontal fluffer feeder, the main purpose of which is to condition the cement so that it will flow freely.

The transport of finished cement through these pipe lines requires the constant discharge of compressed air to maintain the fluidity of the cement. All air compressors are located close to the pumps, making it possible to regulate accurately the air supply necessary for each pipe line.

Piping for this plant is wrought iron. The contractors were The Frank Ricker Estate, Easton, Pa.

Installing Steam Gauges

I have often found steam gauges and controls which were ruined because it was neglected to install a siphon (pig-tail) between the gauge or control and the steam supply. Before installing a control unit, manufacturer's data regarding installation details should be referred to.

When a gauge or control becomes inoperative, inspect the siphon for a plugged condition. This happens at times and it is well worth the effort to blow through the siphon to determine its condition. Brass (or equivalent) siphons should be used to avoid possible obstructions due to corrosion.—HAROLD J. TAYLOR.

Boiler Combustion Space and Burner Control

THE EDITOR.—I would like some information on oil burners for firing heating boilers. What amount of Btu's per cu ft is the most economical for the variable load obtaining over the heating season? What combustion space is required for best efficiency, and which type of control—on-and-off or high-low—has proved most satisfactory, for gun type and horizontal rotary burners using No. 5 oil? We have two boilers, about 125 hp rating each.—G. W. (Plant Maintenance Engineer.)

REPLY.—Possibly the two most controversial subjects related to oil burner applications to heating plants are those of firebox design and burner control. There is good reason for differences of opinions, as there are many types of burners and boilers, and improvements in control are continually being made. Nevertheless, it is possible to discern certain trends and tendencies in general practice, and to establish average values of the variables.

The firebox question can perhaps be handled more definitely than that on control. Data are available on combustion chamber design, but it must be borne in mind that these data are based upon operating performance and observations from general practice, and that little if any actual laboratory work has been done on commercial sizes of boilers. Again, there can be different interpretations of data, depending upon what factor is considered to be the most important. It is necessary to take an average viewpoint, which will not favor any one factor.

A Question and Answer

For domestic and small commercial (up to about 5,000 sq ft E.D.R.) oil fired heating plants, the rate of heat release with conventional boilers should be about 30,000 Btu per cu ft of combustion volume; for larger heating boilers this can be increased up to 40,000. By "combustion space" is meant the total free volume in which combustion can occur and in which the gases of combustion can expand and undergo turbulence before entering flue passages or striking against water tubes. In small residential boilers only about 20 per cent of this total volume will be enclosed within refractory; the remainder will be up within the water-backed walls of the boiler itself. As the size of the unit increases, the percentage of combustion space enclosed within refractory will also increase, up to as much as 70 or 80 per cent in large commercial heating boilers. Naturally, the higher the percentage of combustion space contained within refractory-lined space, the better will be combustion, but this percentage cannot be satisfactorily increased by extending the firebrick walls up and thus shutting off boiler surface from exposure to the fire. The proper way to secure additional combustion volume is to pit the boiler setting.

Pitting the Boiler

In the majority of commercial heating installations it is necessary to pit the boiler setting for another reason, anyway; this is the required clearance between the atomizer or nozzle center and the floor. Most heating boilers are regularly set on 12 in. or 14 in. bases for hand firing. If it is attempted to install the burner within this base clearance, carbonization on the floor is almost bound to result. So the boiler setting should be pitted to avoid this, as well as to secure the required combustion volume. In addition, it will be found that secondary air ports can more readily be provided under the burners when a good pitting job is done under the boiler. For most draft conditions, the required secondary port area is about 1.5 sq in. per developed boiler horsepower, or 1 sq in. per 100 sq ft E.D.R.

There should be no radical difference between firebox design and combustion volume for a gun type burner against a horizontal rotary, except that the former takes more of its air as primary, and so should not need as large a secondary air port (speaking now of commercial work, for on domestic gun types it is rarely necessary to use secondary air at all).

The shape of the firebox is also important, but this cannot be discussed generally as it depends largely upon the type of boiler.

Intermittent and High-low Control

The preceding discussion has assumed a constant rate of firing, as with automatic intermittent control. The design is then made for the maximum load, and the oil burner is either operated at that rate, or is stopped entirely. If, on the other hand, the burner is to operate as high-low fire, then it will be better to size the firebox to the average rate which will exist after the initial heating up in the morning, for since the size of the firebox cannot readily be altered, it is logical to have the box suited to that size fire which prevails most of the time. Hence, in reference to the question on control, here is the first advantage of intermittent or on-and-off control—the firebox can be sized for a fixed rate of firing, whereas on the high-low method the firebox will be correctly sized only some of the time, and the most usual prevailing rate should determine the size.

Other advantages of full automatic intermittent operation are: Little or no attention need be devoted to the burner through most of the daily periods of heating; the control can by some means or other be synchronized to heat requirements and so building temperature can be closely controlled, avoiding overheating and underheating, or wide variations in building temperature.

Against intermittent control are the facts that each time the burner stops the firebox cools off, resulting in a loss of heat and a short period of poor combustion conditions when the burner re-starts and has again to heat up the box. Also, alternate heating and cooling of the boiler and refractory probably throw some additional strain on the materials, but as yet no definite information can be given as to the extent of the resulting damage.

If the burner is to be used during the summer months for heating domestic hot water by some type of indirect water heater, then it will be found a decided advantage if the burner is fully automatic. For when the burner and boiler handle only the small water heating load, steam is raised so rapidly that it will be necessary to shut the burner down shortly after starting it, if it is not an automatic burner. But under automatic control, the burner will stop and start as frequently as needed, either from control of an aquastat on the hot water or from a pressurestat if the boiler runs under pressure while heating hot water.

For boilers of the size indicated above, 125 hp, it might be well to consider a combination of intermittent and high-low, under which arrangement the fire size would be modulated from high to low as the boiler pressure increased, but at the maximum desired boiler pressure, or at a signal from any temperature control device, the burner would stop entirely, and remain off until either the pressure dropped or until the temperature control again called for heat.—KALMAN STEINER.*

*Ace Engineering Co., Chicago, Ill.

Heating · Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

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Progress in Air Conditioning in the Last Quarter Century

By W. H. Carrier* (*MEMBER*), Newark, N. J.

OUTSIDE of the engineering profession, which has been interested for many years in the problems of ventilation, air conditioning today is considered a new art. That it is not a new art is sufficiently attested to by the fact that just a quarter of a century ago it had been sufficiently developed from an engineering and commercial standpoint to attract the attention of the Program Committee of the *American Society of Mechanical Engineers*. So, to the writer's surprise, an urgent request was received from that Society to prepare and present a paper on Air Conditioning. The date of this request was the Spring of 1911.

Development of the Art Prior to 1911

At this time there had been organized at least three concerns, wholly or partly, in the air conditioning field, S. W. Cramer, Charlotte, N. C., in the textile field, Warren Webster & Co., Camden, N. J., who had started an air conditioning department, and the Carrier Air Conditioning Co. of America, incorporated in 1908 as a subsidiary of the Buffalo Forge Co. In addition, there were also a few contractors who had become interested in air conditioning and had made some installations. Most notable among these was W. L. Fleisher, who has since contributed considerably to the art.

That date probably marks the first recognition of air conditioning as a distinct art in the engineering profession, while the present date, exactly 25 years later, properly may be chosen as the date of the first general and recognized public acceptance of air conditioning as an essential factor among the conveniences of our modern material civilization. Not only does this acceptance now prevail among all classes in America, but it is also most assuredly reached in all parts of the civilized world, especially in the countries which the writer had occasion to visit recently, South Africa, India, Japan, Australia, as well as Europe.

Therefore it may not seem amiss, at this particular time, first to outline the state of the art at the time of the first engineering presentation 25 years ago, second, the history of the developments that led up to the existing status and, third, and more especially, to point out the significance of certain vital developments which have made possible its recent general public acceptance.

As a result of the request from the *American Society of Mechanical Engineers* for a paper on air conditioning, a treatise was prepared by the author entitled, Rational Psychrometric Formulae,—Their Relation to the Problems of Meteorology and of Air Conditioning. Since an intensive study had been made by the writer on this subject during the previous 9 years, it was only necessary to assemble and arrange experimental facts and mathematical deductions to put this material in shape for presentation. However, upon the submission of this paper, the Program Committee immediately added a request for a companion paper to be presented at the same meeting in December, 1911. This was to give a picture of the practical side of air conditioning, as well as its more theoretical, mathematical and physical aspect. A compliance with this request was not difficult owing to the availability of previously prepared data. This companion presentation was entitled, Air Conditioning Apparatus—Principles Governing Its Application and Operation.

Assistance was given in the preparation of this paper by F. L. Busey. These two papers presented a very complete picture of both the theoretical and practical aspects of the art as then practised by the Carrier Air Conditioning Co. Not enough was known, at that date, about the then competitive systems to permit their inclusion. The Cramer system was applied, at that time, almost exclusively to textile mills with atomizing spray units distributed throughout the mill with a smaller number arranged to take all or a portion of outside air. His control system originally used wet- and dry-bulb thermometers actuating an electric current. His later and greatly improved form of mechanically operated hygrostat had just been introduced.

As a basis for clearer understanding of the state of the art at the time these papers were presented 25 years ago, a brief history of its development will be interesting.

While the term *air conditioning* has become almost a household word, and so far, there seems to be no other substitute which will simply convey the same idea, its origin is not well known. Although the term *air conditioning* was employed as a part of the name of the Carrier Air Conditioning Co., the first company to broadly enter this field, it was actually originated by S. W. Cramer of Charlotte, N. C., whose name has already been mentioned. About 1907 Mr. Cramer presented a paper before the *National Cotton Manufacturers Association*, on his system of humidification and humidity control for textile mills. He showed how the moisture content of a product followed the moisture content of the air, referring to work done by Schlessinger of France and others in this field of study. From this he argued that the control of the moisture in the air would necessarily control the moisture content in the product. The measurement and control of the moisture content in textiles was then generally known in the trade as *conditioning* and he proposed the logical term of *air conditioning* for the means which would maintain a desired humidity in the room where textiles were processed. Thus, the term of *air conditioning* applied originally only to the control of the moisture content of the air in reference to its effect on hygroscopic materials. In the adoption of the term the following year,

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Paper presented at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS at the Joint Session with the *A.S.R.E.* June, 1936, Buck Hill Falls, Pa.

in the name of the Carrier Air Conditioning Co., it was intended to have a broader application than this and to include, beside humidity control, air cooling, heating and cleaning, as well as the general control of ventilation. Since that time others have attempted to broaden or to use the term more loosely, as for example, where a disc fan is employed to move the air, or where a warm air furnace is provided with a fan and a moistening means; however, although called *air conditioning,* these last named applications obviously are not in accordance with any true conception of the term.

Like most industries, air conditioning developed as a result of a realized but unfilled need. Also as in many industries, other developments have been greatly accelerated by the fortuitous discovery of certain basic principles which could be applied advantageously to the improvement of the art.

The author's attention was first directed to the possibilities in this field by a late member and past president of this Society, W. S. Timmis, consulting engineer, of New York City. Mr. Timmis had been retained by a Brooklyn lithographer to design, among other things, a heating and ventilating system for his plant. The lithographer had told Mr. Timmis of his difficulty with humidity, both in winter and summer, and Mr. Timmis had made some study of the possibilities of dehumidifying in summer by use of liquid calcium chloride, as well as by use of condensing coils. It was recognized by Mr. Timmis that nowhere was there any equipment manufactured for such a purpose, and, through J. I. Lyle, a request was made to the Buffalo Forge Co. to undertake a series of experiments relating to the possibility of dehumidification of the air in summer by one or both of these methods.

Since the author, who was then an employee of the Buffalo Forge Co., had just completed his first self-assigned research work on heat transmission in air heaters, he was, naturally, assigned to this project. These experiments were conducted through the summer of 1902 and in the early part of 1903. Aside from some interesting data on greatly increased factors of conductivity of cooling coils in moist air and upon the practical absorption rates of concentrated calcium chloride solution, little practical result was accomplished. However, specific information of the existing data on atmospheric moisture was obtained principally from the Weather Bureau's psychrometric tables and consideration was also directed to the fact that when calcium chloride, or any other substance, absorbed moisture out of the air an exactly corresponding amount of latent heat was released in the form of sensible heat. This phenomenon, submitted in the report at that time, was carefully analyzed. On account of its heating effect and for other reasons, the use of calcium chloride, as a dehumidifying agent, was not considered practical. However, the observation of this *one* phenomenon led to a train of thought, which eventually was to become important. This experiment disclosed the inter-relation of latent and sensible heat in the air when its moisture content was altered without the addition or subtraction of external heat. It also led to complementary experiments upon the process of evaporation of water into air and, finally, into the development of the principles upon which air conditioning was founded as presented in the paper entitled, Rational Psychrometric Formulae, previously referred to.

It also led to a further study of the need for devising suitable equipment for carrying out air conditioning processes as well as to thought upon the need of various industries for maintaining atmospheric conditions, independently of external weather variations. So, in the winter of 1903 and 1904, a spray type of air conditioner was finally devised, suitable for such purpose and with definite means of controlling absolute moisture content of the air leaving the equipment. Thus, it became possible to definitely control the relative humidity within an enclosure. Little thought, however, was given at that time to adapting this same process to the absorption of heat generated within an enclosure as the necessary and complementary step of true air conditioning. It was not until 1906 that the discovery was made of the necessary relationship between quantity of saturated air supply and the amount of heat generated within an enclosure.

This disclosure came as a result of the study of the first application of such a system to a cotton mill located near Charlotte, N. C. Like many discoveries, this, when found, would have seemed quite obvious from the beginning. Actually it was not. In this study an interesting fortuitous relationship was discovered between the cooling capacity of saturated air and the relative humidity which could be maintained with varying temperature, that is, that *the differential between the dew point of air introduced and the temperature of the room was practically constant for any relative humidity irrespective of the variation in basic temperature.* For a fixed room temperature, of course, this was obvious and was the foundation upon which the basic patent for the dew point method of controlling relative humidity was obtained.

This spray type of air conditioner, as shown in Fig. 1, with certain modifications, was also used about this time for dehumidification by artificially cooling the spray water and for humidification in winter by heating of the spray

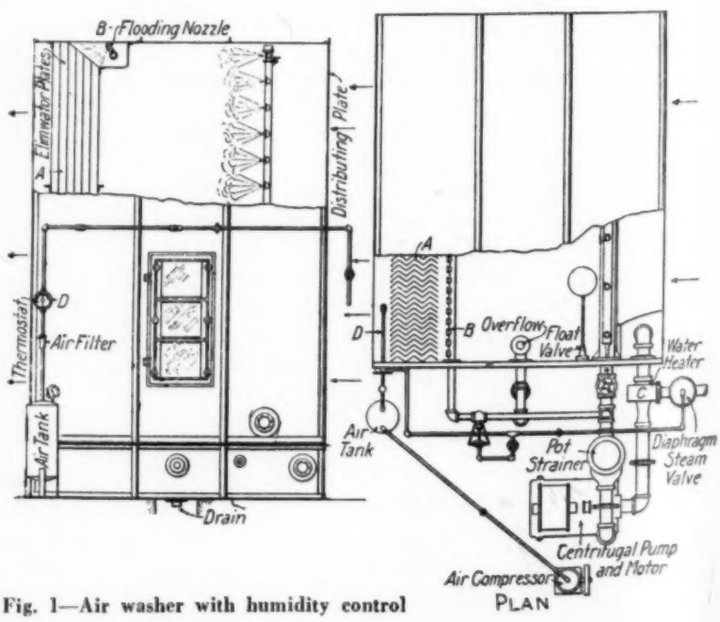


Fig. 1—Air washer with humidity control

water. The general design and features of this early spray type air conditioner are now quite generally adopted throughout the world and there has been little or no change in the design of its essential features in the past 30 years.

Air washers for cleaning air had been designed and had come into general use prior to this time. There were three pioneers in the field of air washers whose names should be mentioned, one of which was Joseph McCreery, who first designed an *S* type of air washer with sprays and eliminators for use in ventilation equipment on boats for the Great Lakes. The principal air washer built at this time, was that designed by Mr. Thomas, of Thomas and Smith at Chicago. This air washer did an excellent job of air cleaning and elimination of free moisture, but the type of sprays employed was not suitable where an exact control of the moisture content was required. There was also a combination of fan and air washer manufactured by Zelwieger of St. Louis, which seemed, for a time, to have some meritorious features, particularly that of space saving.

The types of eliminators employed at this time, however, while efficient in air washing, were not adequate for proper separation of a finely divided spray such as proved to be required in air conditioning.

The method of spray production and distribution was also a matter of concern. Some type of nozzle in which the water was distributed and broken up into fine particles by means of centrifugal action was desired for this function. A simple type of nozzle which had already been developed was selected, which operated by hydraulic action, producing a rotating stream of water through the orifice which, upon issuance, burst into fine particles spread over a wide area. There are two or three methods of producing this rotation, all of which are now in use. The principal requirements in design are simplicity, freedom from clogging, and ease of cleaning.

The general type of nozzle first adopted over 30 years ago, is now the one most generally employed. This type of nozzle was actually invented by a horticulturalist for the purpose of spraying insecticide and supplants older designs which were found unsatisfactory. This is an interesting illustration of how one art may borrow, with profit, from another.

Following the development of satisfactory equipment and processes of controlling the humidity of air, together with the discovery and analysis of the physical laws involved, there was a rapid development in application to industry starting first with textile mills. Here the problem was always one of increasing, as well as controlling relative humidity combined with cooling to remove the large amount of heat generated by the textile machinery.

To quote from the introductory paragraph in the paper Rational Psychrometric Formulae: "The application of this new art to many varied industries has been demonstrated to be of greatest economic importance. . . . In many other industries, such as lithographing, the manufacture of candy, bread, high explosives and photographic films, and the drying and preparing of delicate hygroscopic materials, such as macaroni and tobacco, the question of humidity is equally important." Mention was also made in this publication of the desirability of *application of air conditioning to mines*. This will indicate the commercial status of air conditioning 25 years ago.

In this paper a new theory of psychrometry was also outlined, based on the method of determining the temperature of adiabatic saturation. The entire theory was embodied in four significant and four basic laws or principles as follows:

"a. When dry air is saturated adiabatically the temperature is reduced as the absolute humidity is increased, and the decrease of sensible heat is exactly equal to the simultaneous increase in latent heat due to evaporation.

"b. As the moisture content of air is increased adiabatically the temperature is reduced simultaneously until the vapor pressure corresponds to the temperature, when no further heat metamorphosis is possible. This ultimate temperature may be termed the temperature of adiabatic saturation.

"c. When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air and is unaffected by convection; *i.e.*, the true wet-bulb temperature of air is identical with its temperature of adiabatic saturation.

"From these three fundamental principles there may be deduced a fourth:

"d. The true wet-bulb temperature of the air depends entirely on the total of the sensible and latent heat in the air and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant."

The heat content or total heat of the air was calculated in this paper and was shown to be determined by the wet-bulb temperature. A chart known as the Psychrometric Chart was devised which presented the relationship of wet- and dry-bulb temperature, humidity and total heat. This chart has since formed the basis for all air conditioning calculations, and has permitted an easy solution of all air conditioning psychrometric and drying problems on the assumption of a standard barometric pressure. Formulae were developed which permitted the construction of similar charts for other barometric pressures or the calculation of special relations not embodied in the original chart.

It will be noted that for all practical purposes that these original laws are generally accepted today for engineering purposes. It should be observed, however, that it has since been shown that there is a slight error in the assumption that the wet-bulb temperature is identical with the temperature of adiabatic saturation. Only one error was originally considered, and that was the error due to radiation. It has since been shown, however, that there is another compensating error, which, for practical purposes, is so slight as to be negligible. This departure is caused by a greater rate of diffusion of water vapor than that of air, so that theoretically it is possible to have a wet-bulb temperature lower than with the temperature of adiabatic saturation. This discrepancy is so small, with water evaporating into air, that it is noticeable only with the most refined thermometer readings. Actually, as it tends to counteract radiation of air, the wet-bulb temperature reading coincides almost exactly for all practical purposes with the true theoretical temperature of adiabatic saturation. This is a fortuitous relationship existing with water and air but does not hold as well with other combinations. This discovery is the principal contribution which has been made in the theoretical field since the time of the publication of the first paper. A further study of the radiation error of the wet-bulb thermometer was also presented by the author, with D. C. Lindsay, at the Annual Meeting of

the *American Society of Mechanical Engineers* in 1924. This discussion gives a detailed account of further research done subsequently in this field. The important point, however, is that for engineering purposes in the field of air conditioning, the relationships given in 1911 are still basic and accurate.

In the design and manufacture of air conditioning apparatus there has been considerable advancement, as might be expected. The early status of the art in reference to apparatus and its application is quite fully given in the second paper Air Conditioning Apparatus.

The construction of the humidifier and the dehumidifier is still arranged substantially as used in the original design. Improvements occurred primarily in the simplification of control equipment and in methods of water cooling for dehumidification or refrigeration. The *dew point* method of control, however, probably remains as important as at the date of the first publication. It is now in general use principally because it is a basic air conditioning principle.

A considerable portion of the paper Air Conditioning Apparatus was devoted to a mathematical analysis of experimental data on heat transfer which is important in heating, ventilating and air conditioning fields. It is believed that this was the first engineering publication of the theory of heat transfer between a surface and dry or moist air at varying velocities. Some minor corrections would be made if this theory were to be presented today, but in general, time has proven it most useful and accurate.

At the time of writing this paper, but little use was made of cooling coils or cooling surfaces in air conditioning and in reality this method has played a part of little importance until the last few years. Today its increasing commercial importance has been made possible by two great advancements, first, in improved surfaces and second, the introduction within the last 5 years of new refrigerants. These developments will be discussed later.

In the 1911 paper there is complete discussion of the theory of heat transfer and of air cooling and dehumidifying with cooling coils. This same theory is in general use today in determining intricate calculations. The relationship of the increment of latent heat per pound of air to increment of sensible heat per pound of air is exactly the same theory as employed today. It also shows the by-pass effect of coil surface and the correct method to be employed in calculation of the relative humidity, the moisture content and temperature of the air leaving the coil surface and emphasizes the discovery that the air is not necessarily saturated. These subjects are discussed in this paper under the headings: Air Cooling and Dehumidifying with Cooling Coils, Rate of Transmission Between Air and Water Where Condensation Occurs, Moisture Content of Air Leaving Surface Dehumidifier, and Theory of Convection with Forced Circulation.

As this publication has been out of print several years, it is much less well known to the engineering profession than the first paper, but in many respects it has nearly equal engineering value today, especially in the light of recent developments toward unitary air conditioning equipment with surface cooling.

Up to 1911 and for 10 years thereafter, air conditioning was employed almost entirely in industry. It was not realized previously the tremendous effect it was to have later as applied to requirements of human comfort and particularly in summer cooling in connection with refrigeration. For this reason the public has heard little of it until recent years.

This was true in spite of the fact that the author wrote a catalog in 1905 on air washers for the Buffalo Forge Co. in which the advantages of application of this type of air washer to cooling and dehumidifying processes were emphasized and it was predicted that it would be used in the cooling of churches, theaters, hospitals, etc., in the near future. This prediction, while it has been since proven essentially valid as to method, was entirely wrong as to estimate of time required for public acceptance.

Reference should be made to an interesting paper on Early Comfort Cooling Plants by G. R. Ohmes and A. K. Ohmes in the June 1936 issue of *Heating, Piping and Air Conditioning*. These attempts at comfort cooling range from the use of ice, as early as 1880, to a mechanical refrigeration installation reported in 1898.

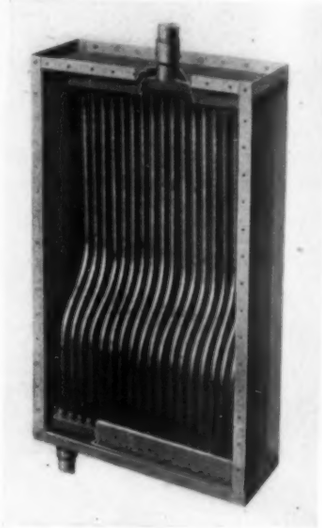


Fig. 2—Improved heat transmission surface for heating and cooling

The earliest comfort cooling installation using mechanical refrigeration of which the author has heard is that cited at a recent meeting of the *Refrigerating Machinery Association* by C. W. Vollmann, president, Linde Canadian Refrigeration Co., Ltd., Montreal. Mr. Vollmann tells of an installation made by the English Linde Co. in about 1887 using ammonia refrigeration to cool a Rajah's palace in India.

Improvements in the Art Since 1911

Having discussed the status of the art 25 years ago in relation to present practices, it is well to survey and analyze the great improvements that have taken place since that date, namely:

1. Scientific measure of human comfort.
2. Improved heat transmission surface for heating and cooling.
3. Improved methods of heat removal (refrigeration) including,
   a. New and improved types of refrigerating machines.
   b. New refrigerant media.
4. Improvements in the methods and apparatus for air distribution and humidity control.
5. Improvements and simplification in the method of dust removal (air filters).
6. Adequate lowering of objectionable sound level of ventilation and air conditioning systems (sound absorbers).
7. Development of reliable low cost unitary cooling and air conditioning equipment.

8. Extension of the application of air conditioning to new fields.

Scientific Measure of Human Comfort

An important scientific contribution to the field of air conditioning has been the determination of the effect of temperature, humidity and air motion upon human comfort and upon efficiency of industrial workers. The earliest work done in this field in this country was that of Dr. E. V. Hill, Chicago, Ill., who first published a synthetic chart in which all the component factors of ventilation were analyzed and evaluated. Among these was the relative effect of temperature and humidity. Dr. Hill had conducted a number of experiments in Chicago, which indicated that the wet-bulb temperature was a controlling factor in sensation of warmth. The validity of this finding, under certain conditions, was questioned by a committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, who were to pass upon the adoption of this chart. As a result, it was decided that the newly established Research Laboratory of the Society should determine the facts regarding this important phase of ventilation. A series of carefully conducted research studies were made, which have since become classical and accepted in all parts of the world as true measures of sensation of warmth, although the cooling power of the kata-thermometer, developed at an earlier period by Dr. Leonard Hill of England, is still preferred by some and is particularly useful in the study of ventilation conditions in deep mines. The results obtained by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS are of the greatest value in the practical application of air conditioning, as they provide a definite measure of the factors producing comfort in an air conditioning installation and permit definite standards to be established.

Improved Heat Transmission Surface for Heating and Cooling

The pioneer work in this field was probably done by L. C. Soule in conjunction with the author and other associates. The heat transmission surface shown in Fig. 2 was the first type of compact, highly efficient, light weight, non-corroding surface to be introduced and become commercially successful.

The development of a surface of this design had long been desired by air conditioning engineers and several attempts had been made to develop a surface of this type. The first essential was a non-ferrous metal such as copper, brass or aluminum, which would not be affected by the moisture in air conditioning systems. Reheater coils, when standing in conditioned air, corrode quickly, making it impossible to use wrought iron surfaces unless hot dipped after formation at excessive cost. Cast iron stood up well, but the rust forming on the surface was often objectionable by contaminating the air stream with iron oxide dust. Where such conditions could not be tolerated, it had to be sherardized at considerable cost and only then with partly satisfactory results.

The weight and space occupied by wrought iron and cast iron heaters were also an important consideration, especially in the use of reheaters placed in the discharge area as was the preferred practice in certain air conditioning applications. If ferrous surfaces were employed for cooling coils, they had to be hot dipped to prevent corrosion and if direct expansion was to be employed, they had to be welded, largely on the job, because of the great weight and bulk on the larger installations of such construction. This was both expensive and unsatisfactory. A non-ferrous surface had to be provided with expensive materials, of which the cost, if prime surface alone was employed, would be prohibitive or else construction would be flimsy and therefore unsatisfactory. This meant the adoption of some form of extended surface in which a maximum amount of surface could be provided with a minimum amount of material and still retain the full thickness and strength of the parts subjected to mechanical and expansion stresses. The greatest obstacle was to provide a suitable assembly of the material for this purpose; which could easily be made hermetically tight and structurally strong, and at the same time allow freedom for expansion and contraction; that would endure high pressure and water hammer; that would also permit ease of assembly of smaller units to create a larger unit and which should be provided with standard casings to permit ease and accuracy of assembly in the field.

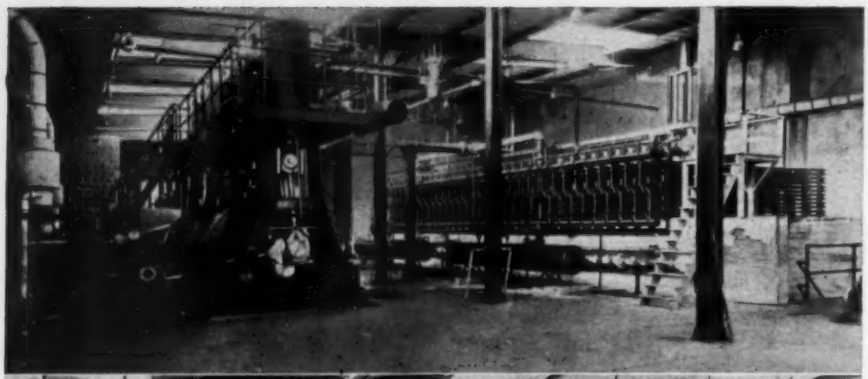
The development of a surface having these desirable characteristics was first accomplished with some success with the coil shown in Fig. 2, which was built in 1922 and presented to the public in 1924. There have been many improvements in the original construction, so that for the last 5 years or more this and other competitive products have met all these stringent requirements, providing a surface fully adaptable to the purposes of air conditioning at a far lower installed cost than the less satisfactory construction available in 1911. This development provided a low cost, highly dependable surface which made practicable the design of unit air conditioners and coolers. It should be considered one of the basic achievements in the air conditioning field since 1911. The complicated calculations, for determining the dehumidifying effect and heat transfer capacity of this surface used in cooling coils, have been standardized to give results of great accuracy. The method of calculation follows exactly the procedure given in the 1911 paper on Air Conditioning Apparatus.

Improved Methods of Heat Removal

New and Improved Types of Refrigerating Machines

In 1911, and for several years thereafter, there were no practical methods of water cooling for air conditioning, except to direct the water over a series of expansion coils, known as Baudelot coils, into a tank. This required the use of an insulated space or Baudelot room, usually separate from the equipment. This arrangement was not only cumbersome, but expensive. However, at that time, it was the most satisfactory method of cooling water.

Another method which prevailed in some applications, where carbon dioxide was used, was to place coils in the spray chamber of the air washer with the addition of flooding nozzles. This design resulted in a combination of the old *bunker coil* type of air cooling with the later type spray cooling. The success of this arrangement depended upon hand manipulation of expansion valves and was used only in comfort cooling where the variations in humidity were completely disregarded. The control of the load with this equipment presented difficulties as the air conditioning equipment was, of necessity, located



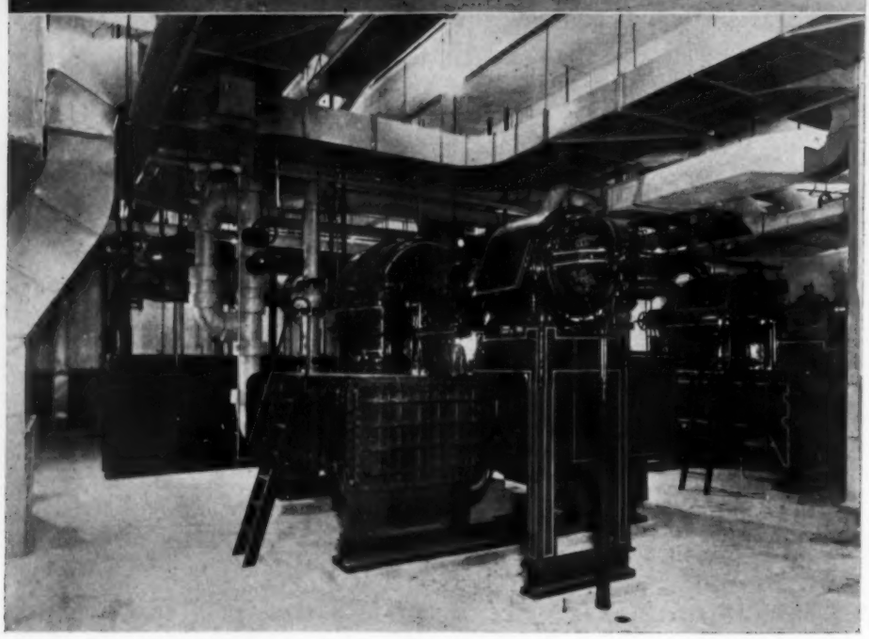


Fig. 3—(top) 350 ton ammonia refrigeration equipment for air conditioning (1918)

Fig. 4 — (bottom) 450 ton centrifugal refrigeration installation for air conditioning (1928)

at some distance from the refrigerating equipment. Hand operation of expansion valves was a practical obstacle which was unsatisfactorily met by giving a fixed setting day by day and running the refrigerating machine at full capacity. This method was wasteful of power and gave no control of humidity conditions. Automatic control was not used on this equipment and in fact was impractical. The operation with Baudelot coils, while permitting a perfect humidity control by the *dew point* method, was still open to the objection of hand manipulation of expansion valves and consequent waste in power consumption. Baudelot coils were generally allowed to ice-up at low loads and the suction pressure permitted to drop.

Air conditioning engineers had long realized the need of some improved type of refrigeration which would automatically respond, first to the demands made by varying loads in the air conditioning system, and second, would cool directly the water in the circuit to a definite point without danger of freezing and thus avoid the use of the expensive, cumbersome and otherwise objectionable Baudelot cooling room. Early types of refrigeration equipment used for air conditioning applications are illustrated in Figs. 3 and 4.

New Refrigerant Media

If a single factor were to be chosen as having the most outstanding influence in bringing about the wide spread adoption of air conditioning and summer cooling, existing today, it is probable that development of new and improved refrigerants would be given this honor.

Early in the art, engineers appreciated the hazards in the use of ammonia or sulphur dioxide to which most refrigerating machines were adapted, inasmuch as a break in the pipe would immediately convey asphyxiating gases to occupied spaces. For this reason the use of direct expansion coils was precluded and even with the use of Baudelot coils, these gases would be picked up by the water and disseminated into the air by the spray. Practically the only safe protection was to use an intervening medium such as brine with an intercooler to cool the water. This naturally was expensive to install, maintain and operate since it lowered the efficiency of the refrigerating cycle.

Carbon dioxide, which was generally acknowledged as a relatively safe refrigerant, presented great practical operating difficulties in an air conditioning system. The power consumption and quantity of condenser water were generally excessive, the automatic high operating pressures required heavy and expensive fittings, producing large refrigerant losses and rendered automatic control impracticable.

It will readily be seen from the foregoing that the state of the refrigeration art, 25 years ago, was most unsatisfactory from a standpoint of rapid promotion and wide spread use of air conditioning for human comfort.

About the year 1902, LeBlanc in France and Parsons in England invented, and patented independently, a steam ejector system of refrigeration in which water was made to boil at temperatures down to and below freezing by the use of brine instead of water.

About 1910 an attempt was made by the Westinghouse Co. to introduce the LeBlanc process in this country. In 1912, the author and his associates investigated this system in an attempt to adapt it to air conditioning. Unfortunately, at that time, the system was not sufficiently perfected to make it economical for high temperature refrigeration, that is, cooling the spray water direct, as the author had in mind. The cost was about double that of the corresponding ammonia system and the cost of operation was about in the same proportion, so that with regret, this possibility was abandoned. Air condition-

ing, at this period, probably had not sufficient volume to warrant necessary improvements in this system, which have since made it feasible for certain air conditioning applications.

In 1918 the author first saw the possibility of using low pressure non-hazardous refrigerants and a series of experiments were undertaken to develop a suitable type of compression system for such refrigerants. After considerable experimentation with other methods, a centrifugal machine (Fig. 5) was finally chosen as the best means for handling such refrigerants. It was first necessary to find a low pressure refrigerant of suitable characteristics in relation to hazard, pressure, corrosion, etc.

The construction of the centrifugal compressor was, at that time, well developed both in this country and abroad, and designs were available giving as high as 78 per cent mechanical efficiency. A greater use of this type of machine was made abroad than here. To adapt the centrifugal compressor to a refrigerant, however, involved many serious problems. Two of the most important were lubrication and the seal. Up to this time, no seal had been devised which would be effective on a centrifugal compressor handling a refrigerant gas. In 1921 a satisfactory design for the seal was finally completed and, with certain modifications, is the same as employed successfully today. Lubrication problems were studied and developed on the first experimental machine in 1922, which was successfully placed in operation in Newark in that year. It is interesting to note that this machine was later sold and is still in commercial operation for air conditioning. A large 750 ton centrifugal refrigerating machine for air conditioning applications is illustrated in Fig. 6.

This innovation in the refrigeration art opened up entirely new possibilities in the field of air conditioning, as it at once gave safety, provided for a varying air conditioning load at substantially constant temperature, was much more compact than the previous system, permitting its introduction in many places where the older type

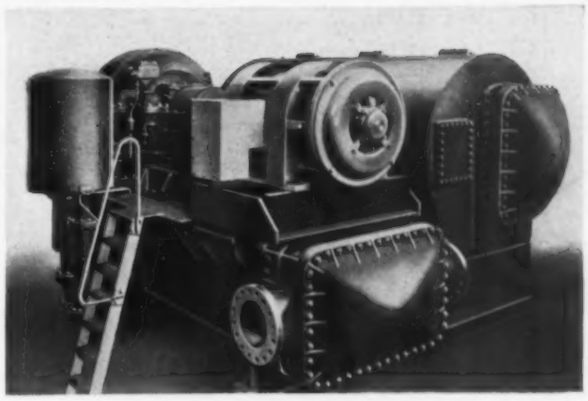


Fig. 6—750 ton centrifugal refrigerating machine for air conditioning (1934)

of refrigeration could not be employed, and was easily made completely automatic. In other words, it seemed, at that time, to answer completely the engineer's requirements for the ideal method of cooling for air conditioning. This was the first innovation employing a new refrigerant and system primarily suitable for air conditioning. During the subsequent period, however, there was a continued development using methyl chloride for small unitary automatic refrigeration and starting with the household unit. Some methyl chloride machines were later employed in air conditioning, but few of these are now in use.

The next and possibly greatest stride was the development by Thomas Midgley, Jr., of a new series of refrigerants which were particularly adaptable to the reciprocating type of refrigeration machine. The best known of these refrigerants is dichlorodifluoromethane (CCl_2F_2). This resulted in a safe refrigerant for use not only in large machines but more particularly in a new range of reciprocating machines (Fig. 7) of smaller capacities, where there was a gap which had previously been entirely unfilled. This refrigerant was made available to the public in 1931. Not only did this refrigerant make application of reciprocating refrigerating machines (Figs. 8 and 9) to air conditioning

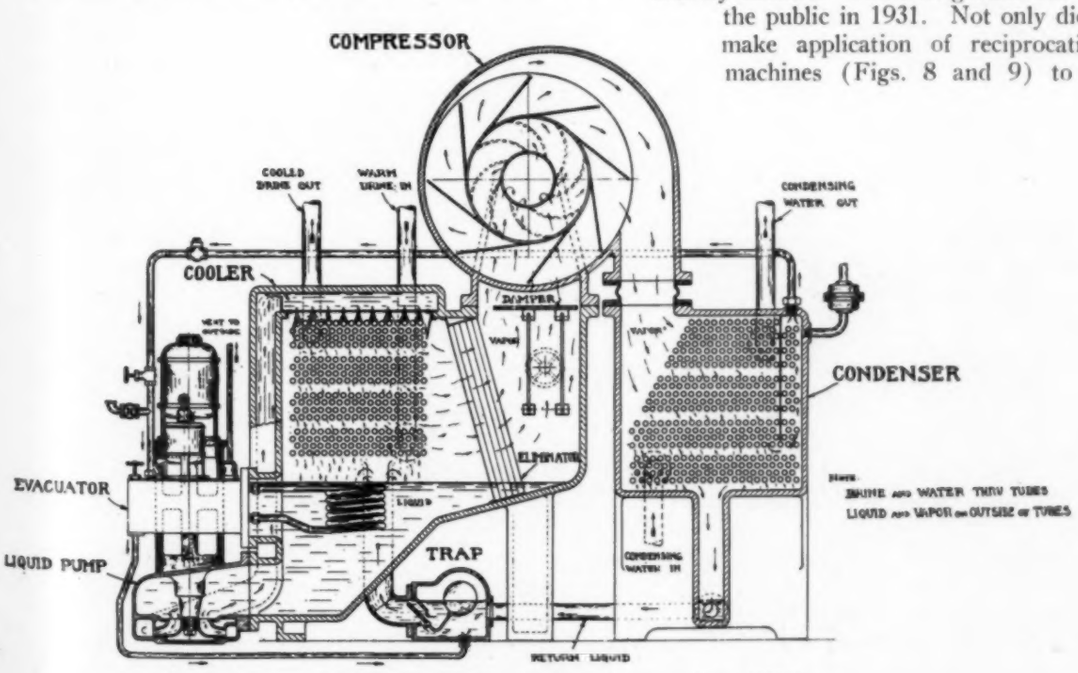


Fig. 5—Typical diagram of centrifugal refrigerating machine (1922)

safe, but in the smaller size machines it permitted a production and installation cost of practically half of that of ammonia machines of similar capacity. It also allowed the use of non-ferrous metals, of only moderate strength, in coolers and condensers. It enabled the use of direct expansion coils of the extended surface type directly in the air stream. Thus, at one stroke, was made practical a great extension of air conditioning to smaller installations, where, undoubtedly, the greatest volume of business is ultimately available.

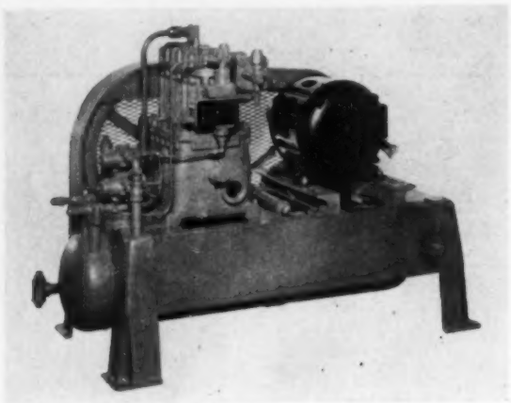


Fig. 7—Dichlorodifluoromethane small self-contained refrigerating machine (1931)

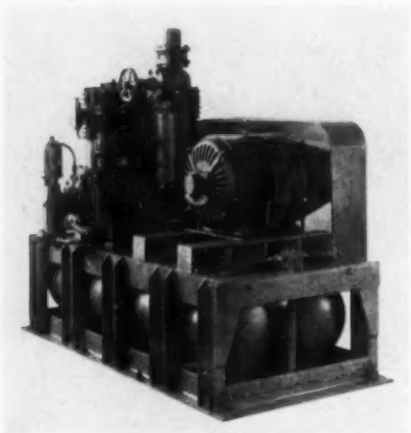


Fig. 8—40 ton self-contained dichlorodifluoromethane refrigerating machine (1935)

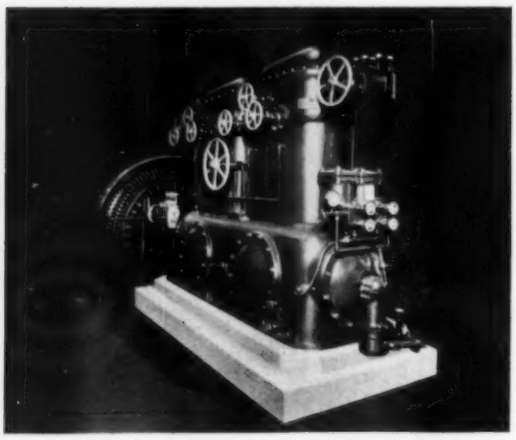


Fig. 9—Large size dichlorodifluoromethane compressor (1932)

In the last 5 years great improvements have been made in the mechanical adaptation of refrigerating machines to these new refrigerants. For smaller machines, mechanical seals are employed rather than stuffing boxes. Efficiencies have been greatly improved. Lubrication has been perfected and automatic controls are now functioning with great reliability. Automatic expansion valves are easily designed and constructed for the new refrigerant because of low working pressures. The suitable nonferrous metals have permitted a much more compact design, essential in unitary equipment.

Recently the steam ejector water cooler, as shown in Fig. 10, has also had a successful development, resulting in a very simple and convenient arrangement for use where steam is available and where there is ample low cost water supply. While this system, in many cases, has disadvantages over the modern compression systems, it has been most satisfactory in marine work and on railroads. It is used extensively in conditioning of railroad coaches, due to the fact that a sufficient quantity of high pressure steam is always available and the condenser problem is solved by the atmospheric condenser, operating on the evaporative principle. For railroad air conditioning each car requires its own power plant and therefore the steam ejector is the simplest type of compression that may be employed.

Since the invention of the LeBlanc process, there have been enormous improvements made in the efficiency of the steam ejector resulting in fair economy. There has also been a considerable simplification which has reduced the cost and increased operativeness of the system. This is a particularly noticeable improvement in its application

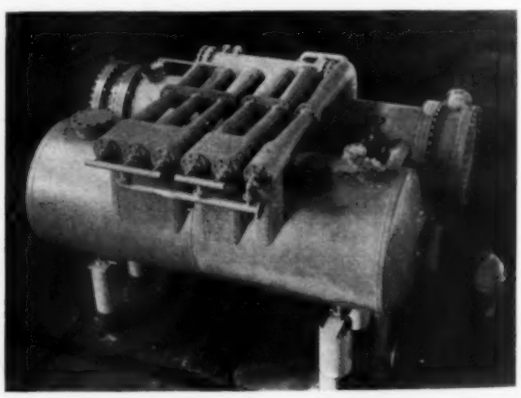


Fig. 10—Steam-jet water-vapor refrigerating machine (1929)

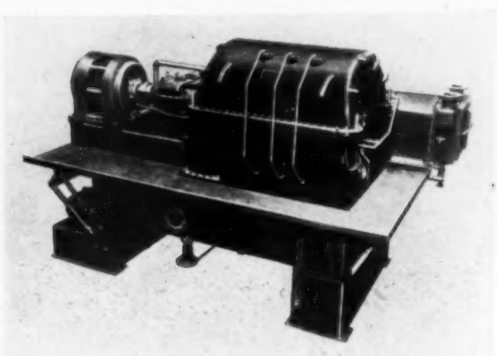


Fig. 11—Centrifugal water-vapor refrigerating machine (1932)

to railroad cars. It is only by such refinement that the equipment has been brought within the bounds of competitive practice.

Another interesting development is that of the water-vapor centrifugal compressor (Fig. 11), which is similar in principle to the LeBlanc process, with the exception that a centrifugal compressor takes the place of the steam ejector. This system requires smaller condenser surface and much less condensing water than the steam jet system because of the greatly reduced volume of vapor to be handled. Both of these systems have the practical advantage that the water is cooled directly by its own evaporation rather than requiring a heat interchanger, as in other systems of refrigeration. Naturally this effects a considerable economy in the thermal cycle. The principal difficulty to be surmounted in the mechanical compression of water-vapor is the enormous volume to be handled, as well as the great centrifugal effect required, owing to the extremely low specific density of water-vapor as compared with other refrigerants employed in centrifugal equipment. However, from an engineering standpoint this is a most astounding achievement.

Improvements in the Methods and Apparatus for Air Distribution and Humidity Control

The former method of ventilation, for ordinary rooms, was to discharge the air through plain registers in the side walls, while for auditoriums the preferred construction was to discharge the air upward from a plenum chamber through mushroom ventilators underneath the seats. This was known as the *upward* system of auditorium ventilation. The first improvement in auditorium ventilation occurred about 1923 when the overhead (or downward) system first was successfully applied in a Los Angeles theater. The air was distributed by means of a series of outlets in the ceiling discharging vertically downward against ornamental plaques, as shown in Figs. 12 and 13. In this way the air was diffused horizontally and radially from each outlet forming a blanket of cooled conditioned air, which, by gravity, settled uniformly toward the floor, thus giving a uniform temperature from floor to ceiling throughout the auditorium. It is interesting to note that this type of outlet was first devised in 1913 to meet special ventilation requirements in a tobacco stemmery in Richmond, where a serious dust problem required large quantities of saturated air to be discharged, without drafts, into the room. This principle is most prevalent today for air conditioning and ventilation. It was a complete reversal of the older practice. In the Senate and House of Representatives at the Capitol building in Washington, D. C., this system now supplants the older system. The success of this method of distribution has been completely established by its general adoption.

Another type of ventilation which has been developed in the last 20 years, which has been most successfully applied to theaters and other buildings, is the ejector system of air distribution, as indicated in Fig. 14. This method of air distribution employs a high velocity jet, formed by relatively high pressure on a nozzle outlet. The air is distributed horizontally, high over the heads of the occupants of the room, and from the back of the auditorium toward the front. The effect of such a series of jets, discharging all in one direction, is to entrain a large volume of air, producing a secondary circulation, and a thorough mixture of highly conditioned air with recirculated room air. The secondary air circulation covers a large area and is uniformly discharged at extremely low velocity. This arrangement gives uniform temperatures within the theater and avoids objectionable drafts. The size of the nozzles may be modified to secure any length of blow required.

This system has many advantages, the principal one being that it permits use of relatively small quantities of highly conditioned air at low temperature which reduces duct sizes and cost of power for fan operation. It is interesting to note that this system was first devised, not for air conditioning of human comfort, but for improvement in the method of air circulation in the drying of materials. This principle was successfully applied by A. E. Stacey in the design of what is known to the trade as the *blue ribbon outlet*. This outlet is placed in the room in the form of a register and has horizontal or vertical slots which are formed in the shape of true rectangular nozzles, as shown in Fig. 15. These nozzles cause ample entrainment and permit the principle of the ejector outlet to be used in rooms of any size, giving greatly improved distribution and a low temperature differential between the air stream and the room. These effects are essential to avoid localized cold spots and objectionable drafts. The quantity of air may be regulated by closing

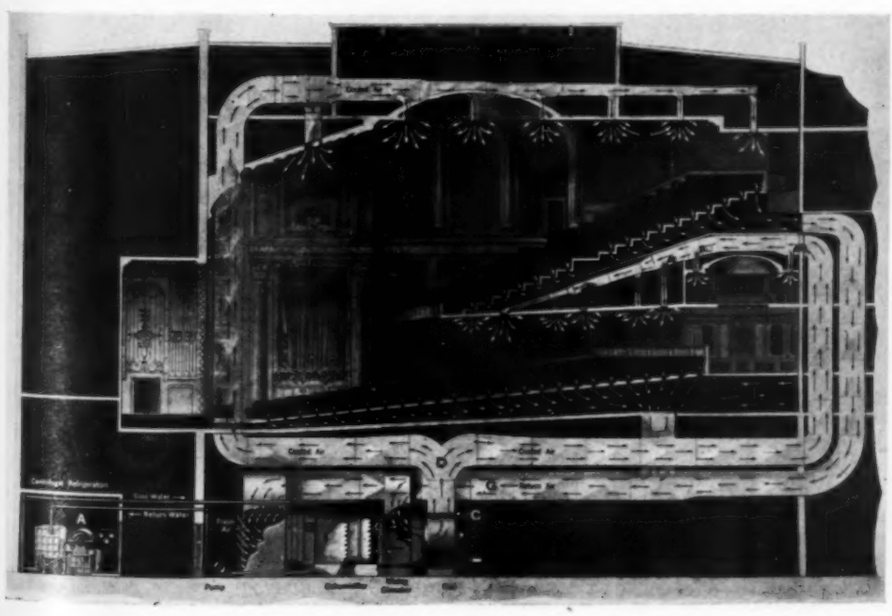


Fig. 12—Downward system of theater ventilation and air conditioning

off any desired portion of the discharge area.

Another application of this same principle is used in individual room cabinets in which the air is discharged upward toward the ceiling. These cabinets are usually placed under windows and are provided with an indirect, light weight heating surface in which steam or hot water can be controlled as in an ordinary radiator. The recirculated air induced by the ejector action is drawn through this heating element contained within the cabinet. When provided with small volumes of conditioned air at about ¼ in. pressure, the cabinet will ventilate, cool, heat and control the humidity of the room as required. The volume of air supplied to the room is also under manual control, so that it may be reduced any amount or closed off completely. This system has proven satisfactory in application to office buildings and provides an ideal system of air conditioning and heating.

Varying volumes of conditioned air in a large number of rooms connected to one system are provided for by the use of a static pressure regulator. This maintains a uniform pressure in the main duct and branches, regardless of the amount of air delivered, so that the ejector action is maintained uniformly effective. This is an important development in exact control and satisfactory operation of air conditioning and ventilating systems.

Another important improvement made in the air distribution is a register which gives positive direction and distribution of air. The cold air, if introduced horizontally, is deflected upward at a slight angle toward the ceiling, assisting in the mixture and diffusion with room air. Still another form of diffuser is one which may be made to discharge the air at any vertical or horizontal angle and, at the same time, spread or diffuse it radially. This diffuser has many important applications

TOP TO BOTTOM

Fig. 13—Overhead target air diffuser

Fig. 14—Ejector system of air distribution

Fig. 15—Slotted outlet ejector system

where the exact distribution desired cannot be determined before installation.

Perhaps the greatest contribution to the art of air conditioning in the last 25 years has been the system of by-pass control devised by L. L. Lewis and improved by W. L. Fleisher. This process, in conjunction with artificial cooling, solves the problem of independent control of temperature and humidity of an enclosure. In some of the older attempts at cooling, humidity was ignored, and the temperature of the air introduced was varied by reduction of refrigeration effect upon the air itself. In such a system it is obvious that when small cooling effects are required there will be little reduction of air temperature with corresponding increase in relative humidity. In other words, when the temperature of the room was controlled by this method, the humidity would vary from possibly 50 per cent to a maximum of over 80 per cent under certain conditions of operation. It is obvious that with this method there was no real control over effective temperature. Moreover, abnormally humid air is objectionable from a comfort standpoint because it does not remove perspiration. The ideal effect in air conditioning is to prevent or remove sensible perspiration without too great a lowering of temperature. The desirable range of humidity for human comfort lies between 40 and 60 per cent and is, of course, related to the temperature as determined by the Comfort Chart. With automatic temperature control, a uniform as well as low relative humidity is an essential of true air conditioning for human comfort.

Previous to the advent of air conditioning for human comfort, it had been the practice in industrial installations to vary the volume of air introduced into the room in order to control the temperature without affecting the relative humidity. The relative humidity was determined by the relation of the dew point of the air to the room temperature. Another method often used supplementary to the above was to add heat artificially, that is, so as to maintain a constant heat load regardless of the requirements.

These methods could hardly be tolerated in air conditioning for human comfort. In the first place, in an auditorium a constant air volume is desired because any change in air volume causes a change in distribution which is objectionable. Second, supplementary heat is frequently not available and is undesirable because of unnecessary load imposed upon the refrigerating system at an increase in operating cost. It is permissible, from a ventilation standpoint, and also necessary for reasons of economy, that a considerable percentage of air be handled in the ventilation system. Advantage of this fact is taken, to by-pass a varying quantity of return air around the conditioner. By varying the amount of returned air by-passed, to the total amount passed through the conditioner, it is possible to maintain a constant dew point at the conditioner and at the same time increase or decrease the amount of conditioned air without affecting the total volume of air circulated. This permitted varying the cooling effect according to the demand, and at the same time maintaining a constant dew point. A reasonably accurate control of relative humidity within the enclosure may be obtained by this method, which is now generally employed in all larger air conditioning installations.

Improvement and Simplification in the Method of Dust Removal

In addition to the air washing produced by the air conditioner, additional cleaning of air for ventilation purposes is quite generally provided by various types of air

Fig. 16—Unit air filter

Fig. 17—Throw-away type air filter

filters. These air filters operate on two distinct principles, first, by actual filtration through a porous substance such as specially prepared pulp paper which strains out and entrains the dirt, and second, by use of units or sections containing a filler of some character which is coated with oil or other viscous substance, providing a tortuous passage through which the air passes. The impingement of the dirt particles upon the viscous surfaces provides the necessary cleaning action required. The latter filters are of two types: first, the permanent type, as shown in Fig. 16, which requires servicing and cleaning, and second, the *throw-away* type, as shown in Fig. 17, constructed of especially cheap material, so that

it may be discarded when it has become filled with dirt. There are also filters which are automatically cleaned which are of a more elaborate construction.

Modern air filters are effective in the removal of dust particles, but are inefficient in removal of smoke or fume. Their value and effectiveness were spectacularly demonstrated about a year ago, during the great dust storms that prevailed in the West. Air conditioned buildings and railroad cars provided with dust filters went through these storms without any serious inconvenience, while other buildings and cars, not so provided, were almost overwhelmed with dust and subjected to great expense for renovation. The air filter has become a permanent part of a modern air conditioning system and will probably continue to be improved from a standpoint of effectiveness, installation and maintenance cost.

Lowering of Objectionable Sound Level of Ventilation and Air Conditioning Systems

Until the advent of air conditioning for human comfort within the last few years, and particularly since application of air conditioning to sound studios and broadcasting stations, little attention had been directed to the subject of noise in the ventilating system. The noise problem was always obvious and frequently so objectionable that it was found impractical to operate the system after installation. This condition could not be tolerated in sound studios, which came with the talking movies, nor could it be tolerated in the broadcasting studios, which must be cooled and ventilated and *must* be quiet. This led to an early study, by air conditioning engineers, of sound prevention and absorption. Quieter ventilation equipment was demanded, and to a degree obtained, but principally the advance was made through a new technique of sound absorption, which has been made so perfect that the starting up or shutting down of the ventilating equipment cannot be detected within the quietest ventilated space.

The theory of sound absorption and the exact calculation of degree of sound absorption has been quite fully developed. Coefficients for various types of sound absorbers are quite accurately determined experimentally so that today the level of sound effects from a ventilating system can be calculated as exactly as the pressure drop in air ducts in the same system.

One of the most successful types of sound absorbers is of cellular construction made up of relatively small rectangular tubes of sound absorbing material nested in parallel to form a unit. These sound absorbers are interposed between the room openings and the ventilating equipment. Outstanding examples of an application of sound absorbers of this character are in the Capitol at Washington, D. C., and the National Broadcasting Studios at Radio City, New York.

The proper utilization of sound absorption methods makes possible application of air conditioning to homes and offices where otherwise air conditioning applications might only substitute one discomfort for another.

Development of Unitary Cooling and Air Conditioning Equipment

The development of standardized unitary air conditioning equipment of various sizes, which can be completely assembled at the factory and easily installed, stands as a real achievement of the last 5 years of this quarter century. This has resulted from the availability of low cost, completely automatic refrigerating machines designed for the new and safe refrigerants, and also from the availability of compact, light weight heat transfer surface. These units are of various types, such as illustrated in Fig. 18, but are all designed to meet the need for a low cost installation which will require a minimum of supervision and servicing. They are especially adapted to use in small restaurants, stores, shops, isolated offices, etc. With the demand for such a unit provided there has, perhaps, opened up one of the largest markets for commercial air conditioning. This market has been expanding with great rapidity within the last 3 years.

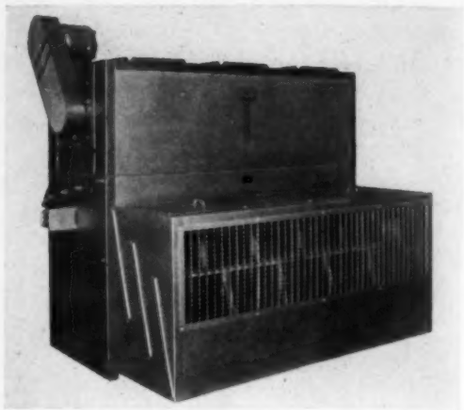


Fig. 18—Air conditioning unit for all year service

Extension of Air Conditioning to New Fields

The last quarter century has been particularly notable for the extension of the air conditioning industry into the field of cooling for comfort. The public first experienced the effects of air conditioning in the successful theater installations within the last 15 years, but perhaps the greatest aid to public acceptance has been the wholesale adoption of air conditioning by the railroads during the last 5 years. The rapidly growing and widespread use of air conditioning is being brought about by the advances in design and materials which make it possible to demonstrate to the small commercial user that air conditioning is a paying investment.

The first demonstration of the possibility of cooling a railway passenger car was made personally by the author at the Baltimore and Ohio shops in 1929. In 1930 two dining cars were equipped with successful air conditioning systems, one on the Baltimore and Ohio and the other on the Santa Fe. The following year three other installations were made. All of these early installations used ammonia, as no other satisfactory refrigerant was then available, and special precautions had to be taken against hazards in the use of this refrigerant. In the following year dichlorodifluoromethane became available and there was also developed a satisfactory system employing a steam ejector and water as the refrigerant. Both of these systems have received wide acceptance on nearly all the principal railroads throughout the United

States and are shown illustrated in Figs. 19 and 20. There are a large number of cars being operated, with the steam ejector system of refrigeration for air conditioning, on the South Manchurian Railway. As far as known, this is the only important installation anywhere outside of the United States and Mexico.

A recent notable extension of the art is the application to mines. A trial installation was made in the Morro Velho Gold Mines at St. John del Rey, Brazil, which was reported in the year 1922. By this application the working conditions in the mines were considerably improved and in 1929 this installation was augmented by an addition of centrifugal refrigerating machines and

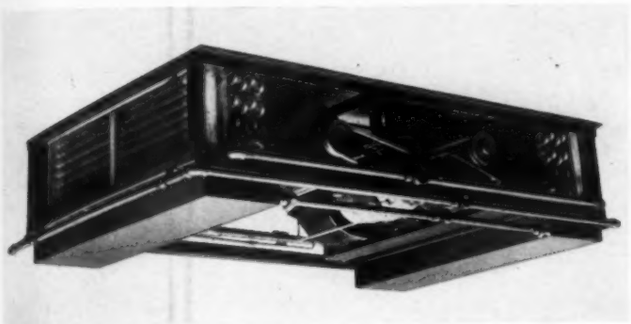


Fig. 19—Air conditioning unit for railway car

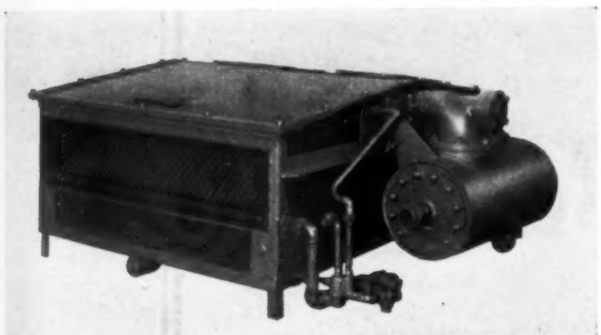


Fig. 20—Steam-jet refrigeration unit for railway car

spray type air conditioners, located at the 6,000 ft level. This latter installation has proven most effective, since it controls the temperature at the working level and permits the extension to any depth within the range of practical cost of mechanical operation.

More recently, in the Robinson Deep, at Johannesburg, South Africa, a 2,000 ton installation was made for conditioning of the 400,000 cu ft of air per minute supplied to this mine. Later it is anticipated that booster installations will be made in the mine at the lower levels. The present depth of this mine is about 8,500 ft and at this exploratory depth economic mining is impracticable without air conditioning, owing to the excessive heat. With air conditioning, it is expected that the practical working depth of this mine can be increased many thousand feet. The Rand Gold Field, in which this mine is situated, at present yields over 50 per cent of the world's gold supply and an increase of the potential yield of this rich district by at least 50 per cent, through air conditioning, is of the greatest significance in maintaining a future stability in the world's economics. This application of air conditioning may eventually have greater influence on world advancement and prosperity than all other applications of air conditioning combined.

Air conditioning installations in homes and private offices are not yet numerous; but equipment is now provided which will satisfactorily meet the demands of this field. The most recent contribution is a portable air cooling unit, as shown in Fig. 21, which can be plugged into a light socket, without any other connections. This employs an air cooled condenser with a motor driven dichlorodifluoromethane compressor in the air conditioning cabinet. The greatest difficulties to surmount in this type of equipment are noise and improper ventilation. It is believed, in recent designs, that these obstacles have been largely overcome.

It is probable that the greatest strides in the general application of air conditioning have been made in the last half of the quarter century. Further improvements will probably be brought about largely by perfection of details of equipment, now already available.

And now in retrospect we see the progress of air conditioning development marked off in decades. 1901 may be said to mark the end of what might be termed The Azoic Age of air conditioning. That is the age in which there had been no development in the field either accomplished or begun. Ten years later, in 1911, air conditioning was acknowledged as a new art by the engineering profession. By 1921 the first successful modern type of installation for public comfort was designed. The beginning of the development of unitary equipment extending the benefits of air conditioning to small users came in 1931. Without thought of prophecy the year 1941 can be anticipated as marking the probable beginning of commercial success and public acceptance of complete air conditioning in the residential field.

In conclusion, appropriate recognition must be directed to the contributions to this development by all branches of the engineering profession. Continued interest and cooperation in development and refinement will accelerate engineering and commercial achievement with the resultant benefits to the public.

Fig. 21—Portable self-contained summer air conditioner

Proceedings of the Semi-Annual Meeting 1936

American Society of Heating and Ventilating Engineers

The Inn, Buck Hill Falls, Pa., June 22-24

THREE hundred and fifty members and guests accepted the invitation of Philadelphia Chapter to enjoy the technical sessions and the entertainment program provided for the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, June 22-24, 1936, at The Inn, Buck Hill Falls, Pa.

One of the enjoyable features of the meeting was the joint session held with members of the *American Society of Refrigerating Engineers,* who were meeting at the same time with headquarters at Skytop Lodge nearby.

The Council and the Committee on Research each held two meetings and other technical and general committees held conferences during the three-day meeting. Amendments to the By-Laws were adopted, nominees were selected to serve on the Committee on Research and the Nominating Committee selected its slate for 1937.

FIRST SESSION—

Monday, June 22, 9:30 A.M.

The Semi-Annual Meeting 1936 was called to order by Pres. G. L. Larson, Madison, Wis., Monday morning, June 22, at The Inn, Buck Hill Falls, Pa., and Wilbur Smith, president of Philadelphia Chapter, welcomed members, guests, and ladies to the Poconos and expressed the pleasure of Philadelphia members for the opportunity of serving as hosts. A brief response was made by 1st Vice-Pres. D. S. Boyden, Boston, Mass.

Amendments to Constitution and By-Laws

The first order of business was consideration of the following amendments to the Constitution and By-Laws, which were presented by R. H. Carpenter, New York, N. Y., chairman of the committee.

Article C-II, *Section 2.* The membership of the Society shall consist of Honorary Members, Members, Junior Members, Associate Members and Student Members.

To Be Amended as Follows: The membership of the Society shall consist of Honorary Members, Life Members, Members, Associate Members, Junior Members and Student Members.

Article B-II, *Section 5.* Any person who has been a member of the Society for fifteen (15) years or more and has retired from business, then upon reaching the age of seventy (70) shall have his dues remitted for the current year and for ensuing years, without surrendering any of the privileges of membership as long as he lives.

To Be Amended as Follows: Any person who has been a member of the Society for 15 years or more, upon reaching the age of 70, shall have his dues remitted for the current year and for ensuing years without surrendering any of the privileges of membership as long as he lives.

Article B-IV, *Section 7:* The dues of a new member of any grade may be pro-rated monthly for the balance of the year but if the amount thus paid is less than five dollars ($5.00) such member shall not be entitled to receive the volume of the Transactions for the year in which he is elected, but he shall otherwise be entitled to all the rights and privileges of membership. Forty per cent (40%) of the pro-rated dues of Members and Associate Members shall be considered as a contribution to the Research Fund and shall be immediately deposited in such fund and shall not be used for any other purpose.

To Be Amended as Follows: The dues of a new member of any grade may be pro-rated monthly for the balance of the year but if the amount thus paid is less than five dollars ($5.00) such member shall not be entitled to receive the volume of the Transactions or The Guide for the year in which he is elected, but he shall otherwise be entitled to all the rights and privileges of membership. Forty per cent (40%) of the pro-rated dues of Members and Associate Members shall be considered as a contribution to the Research Fund and shall be immediately deposited in such fund and shall not be used for any other purpose.

Article B-VIII, *Section 1.* At the first meeting of the Council after the Annual Meeting, the President shall appoint from the members of the Council the following committees consisting of three (3) members each, to act under the direction of the Council:

(a) Executive Committee.
(b) Finance Committee.
(c) Membership Committee.
(d) Meetings Committee.

To Be Amended as Follows: (e) Standards Committee.

Add Article B-VIII, Section 6. The Standards Committee shall consider all questions pertaining to the establishment and revision of Society standards and shall report its findings to the Council.

In accordance with Article C-XVI of the Constitution it was voted that the amendment to Article C-II, *Section 2* of the Constitution be submitted to the membership prior to the next Annual Meeting in the required manner.

Mr. Carpenter moved the adoption of Article B-II, *Section* 5, Article B-IV, *Section 7*, and Article B-VIII, *Sections* 1 and 6. The motion was seconded by J. D. Cassell, Philadelphia, Pa., and when President Larson put the question, the vote was unanimously in favor of adoption.

The first technical paper was announced by President Larson entitled Corrosion Studies in Steam Heating Systems by R. R. Seeber, F. A. Rohrman and G. E. Smedberg. (Published in February 1936 Journal Section, *Heating, Piping and Air Conditioning*). Presentation was made by Prof. R. R. Seeber, Houghton, Mich., and verbal comments were given by W. H. Driscoll, New York, N. Y., who also exhibited some examples of cor-

Prof. G. L. Larson, *President*
A. S. H. V. E.

roded piping taken from the Waldorf-Astoria. Prof. F. E. Giesecke, College Station, Tex., offered some comments on his experience with piping in Texas. S. R. Lewis, Chicago, Ill., W. F. Smith, Philadelphia, Pa., L. P. Hynes, Philadelphia, and N. D. Adams, Rochester, Minn., made comments and the author replied. Written discussions were contributed by R. M. Palmer, New York, D. H. Little and G. C. Eaton, Boston, and T. J. Finnegan, New York.

The paper, Performance of an Underfeed Domestic Stoker by T. G. Estep and D. C. Saylor, was given by one of the authors, D. C. Saylor. (Published in June 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions prepared by R. A. Sherman, Columbus, O., and Prof. D. W. Nelson, Madison, Wis., were read by John James, New York, and other comments were given by Prof. W. H. Severns, Urbana, Ill., and Messrs. Cyril Tasker, Toronto, and L. P. Hynes, Philadelphia.

A. J. Johnson, director of the Anthracite Institute Laboratory, Primos, Pa., presented the paper, Relative Absorption of the Various Sections of a Round Heating Boiler by A. J. Johnson and P. A. Mulcey. (Published in July 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Verbal comments were offered by S. R. Lewis and E. H. Gurney, Toronto, to which the authors replied.

The final paper on Monday's technical program was The Distribution of Steam in Heat Transfer Surface, which was presented by the author, John McElgin, Philadelphia, Pa. (Published in June 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions by H. F. Hutzel, Detroit, Mich., and Prof. F. B. Rowley, Minneapolis, Minn., were given and S. R. Lewis gave an oral discussion.

SECOND SESSION—

Tuesday, June 23, 9:30 A.M.

On Tuesday morning members of the *American Society of Refrigerating Engineers* and the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS gathered for a joint session in the auditorium of The Inn. The officers of both societies were on the rostrum when President Larson called the meeting to order.

W. H. Carrier, Newark, N. J., past president of both societies, was introduced and acted as chairman. He announced the first paper by Prof. C. W. Chamberlain, East Lansing, Mich., entitled, Theory and Practice of the Heat Pump. (See *Refrigerating Engineering*, August, 1936).

Prof. C. W. Chamberlain discussed the principles of a heat pump and reviewed the various historical developments in this field. Many years ago Lord Kelvin proposed a method of automatically heating and cooling which was never reduced to a successful practice because it involved the use of an ingress cylinder and receiver, which had to be kept as nearly as possible at the temperature of the atmosphere. For mechanical heating, the pressure of the receiver was to be kept below that of the atmosphere, whereas for mechanical cooling, the pressure of the receiver was to be kept above that of the atmosphere. Since Kelvin's proposed machine could not be used for both heating and cooling without mechanical modification, it was easy to understand why heat machines were not considered subsequently in accordance with this theory. Consequently vapor compression systems have rapidly replaced those using air or other nearly perfect gases as refrigerants. In practically all attempts

L. S. Morse, *President*
A. S. R. E.

to heat interiors by mechanical means, vapor has been used as a working medium.

One of the principal sources of design difficulties in connection with this type of device, according to Professor Chamberlain, was the available source of heat. Under favorable conditions water could be used as a source of energy, but generally cities would not consent to having their water supplies used for these purposes, as the hazard of freezing pipes would be increased. Kelvin proposed that heat pumps be limited to locations where sea water was available in large quantities. However, there are some favorable locations in this country where water from private wells could be used as a source of heat in winter and for cooling purposes in summer.

A proposed schematic arrangement for heating, cooling and ventilating various types of enclosures was described in detail by Professor Chamberlain in which he pointed out several advantages over the air cycles originally proposed by Lord Kelvin.

The author presented a laboratory device for studying and measuring barrier films on various forms of heat transfer surfaces and stated that as a result of a series of experiments, which have been continued for several years, it was found that when the thickness of liquid films was reduced beyond the range of the compound microscope they possess characteristics quite different from those of thick films of the same liquid. Measurement of these films was finally solved by the development of a compound interferometer. The use of this instrument has made it possible to observe and accurately measure films of thickness equivalent to 6 hundred-millionths of an inch. It was interesting to note that this is the distance over which molecules act and is commonly referred to as the Radius of Molecular Attraction.

When the liquid film was examined with the compound interferometer, with resulting power 200 times greater than that of the compound microscope, it was found that when film thickness was reduced to one ten-millionth of an inch any further attempt to thin it caused it to split in the middle. The thin liquid films were then found to have a laminated structure upon detailed investigation.

A proposed new type of heat interchanger was introduced by Professor Chamberlain which was arranged to split the surface films in the middle. Each separate globule of liquid is seized like a rock in a stone crusher, smashed into a thin sheet and passed downward through the passage with surprising velocity. The foam walls are split in the middle and the liquid contacts all of them. There is a rapid thermal interchange between the downward moving liquid and the thin foam walls and from the latter to an upward moving air. As the foam cells are small, no molecule of air is far from a film wall. When thermal agitation causes an air molecule to collide with the liquid wall, the impact is inelastic and not elastic. If the air molecule rebounded from the transition layer, only a fraction of the impacts would cause a transfer of energy from liquid to air. The impacted air molecule and film is inelastic. The air molecule enters the liquid and makes many impacts with the molecules of the film and, when it finally emerges, it has gained the average energy of the film molecules. Liquid molecules from the transition layer likewise enter the air space and as the air is saturated with vapor, the number of molecules entering and leaving either medium remains constant.

The rate of transfer of heat used in this type of exchanger is high. An engineer observing these films for the first time by means of the compound interferometer referred to them as *living films,* so surprising was the activity of their surfaces.

In this type of heat exchanger the problem of dehumidification in summer and humidification in winter is automatically maintained. The air admitted to the interior of the interchanger is not saturated with moisture since the liquid with which it was in equilibrium had its vapor pressure lowered by the solute with which the freezing point of the foaming solution was lowered. It was interesting to note that when the air was removed from contact with the foaming solution it was below the saturation point of the air.

After this very interesting presentation, a lively discussion was carried on and those who participated were Prof. J. E. Nicholas, State College, Pa., Crosby Field, Brooklyn, N. Y., and Professor Larson, and a reply was given by Professor Chamberlain.

Chairman Carrier introduced J. R. Hertzler, York, Pa., who gave his paper, Application Factors Which Govern the Selection of Refrigerating Equipment for Air Conditioning Service. (Published in July 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). A brief discussion was offered by L. L. Lewis, Newark, N. J., and response was made by the author.

In the absence of D. C. Morrow, Washington, Pa., his paper on Water Supply as Affected by the Demand for Summer Air Conditioning was presented by title and a written discussion was given by L. L. Lewis. (See *Refrigerating Engineering,* June 1936).

In his discussion of the performance of water supply for air conditioning the author pointed out that in the near future the water supply industry must be prepared to compete with the electrical industry in supplying a medium for heat disposal.

To experienced water works engineers it is obvious that the operating costs of these systems will vary widely. Since the proper charge for water service is dependent upon plant value and operating costs, it is equally true that there must be a variation in cost of service to consumers from low rates in the cases of strictly gravity systems to high rates in the cases of the most complex systems.

At the present time in the larger cities of this country the average daily per capita consumption ranges from less than 100 gal to nearly 300 gal, while in the smaller cities and towns the range is from less than 25 gal to 500 gal. This latter high rate is due to heavy industry demand, careless and extravagant use of water, and to leakage in the distribution pipe systems.

Experience indicates that maximum average daily rates during the season of high demand may exceed the daily averages which are based on the average consumption by more than 50 per cent, while the peak hour may exceed the daily rate by more than 125 per cent.

The rate of air conditioning growth may be so accelerated in the future that the demand for water in industry may exceed the available supply in many places, the author estimated. It is indeed unfortunate that this extra burden will be imposed during the season when water supply systems are already carrying peak loads.

Then, too, the load factor chargeable to air cooling will be low, because of the comparatively short season and the variable demand during the day. In general, the peak demand will closely coincide with those now carried, however, they cannot be treated as exactly compensatory. This means that the capacities of all elements of water supply systems must be increased enough to carry the load imposed by the maximum demand.

The prediction of the author was that the additional air conditioning load will fall upon water supply systems and, since water works officials usually have anticipated additional demands before they were realized, it was believed that water for air cooling purposes will be available when water economizing devices are used.

In discussing Mr. Morrow's paper, L. L. Lewis indicated from information which he had collected a maximum demand of 350 gpd per capita and a probable use of 140 gpd per capita for a season of 120 days as the air conditioning requirements for water when neither cooling devices nor evaporating devices were used. By using water cooling devices or evaporating devices, the estimated demand dropped to a maximum per capita demand of 140 gpd and a probable per capita use of 60 gpd for 120 days.

With Pres. L. S. Morse, York, Pa., of *A. S. R. E.* acting as chairman, W. H. Carrier was presented and gave an abstract of his paper, Progress in Air Conditioning in the Last Quarter Century. (Published in August 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). A review of this period in the development of air conditioning was greatly enjoyed by the audience.

THIRD SESSION—

Wednesday, June 24, 9:30 A.M.

The final session of the three-day meeting of the Society at Buck Hill Falls was opened by President Larson on June 24 and D. D. Wile, Detroit, Mich., was introduced and gave his paper, Development of Testing Apparatus for Thermostats. (Published in May 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Two written discussions by B. E. Shaw, Des Moines, Ia., and L. P. Hynes were given.

President Larson introduced L. A. Harding, Buffalo, N. Y., who gave his paper entitled, Pyrheliometers and the Measurement of Total Solar Radiation. (Published in April 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). Written discussions by R. P. Cook, Rochester, N. Y., and K. A. Powell, Minneapolis, Minn., were read and R. A. Miller, Pittsburgh, Pa., presented his comments.

Prof. F. E. Giesecke was introduced by President Larson and gave the paper, A Field Study of the Heat Requirements of a College Building by F. E. Giesecke and W. H. Badgett. (Published in June 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). W. W. Timmis, New York, N. Y., commented on the problems involved in air conditioning residential and larger types of buildings. W. C. Randall, Detroit, Mich., commented on the infiltration problem and S. R. Lewis discussed the matter of infiltration and sun effect in winter.

The last technical paper was given by F. C. Houghten, Pittsburgh, Pa., who presented the subject of Heating Requirements of an Office Building as Affected by Weather Conditions by F. C. Houghten and Carl Gutberlet. (Published in July 1936 JOURNAL SECTION, *Heating, Piping and Air Conditioning*). In a written discussion E. K. Campbell, Kansas City, Mo., discussed the problem of calculating heat loads of buildings of various age and commented on methods of preventing overheating in mild weather.

M. C. Beman, Buffalo, N. Y., in a written discussion, commended the Laboratory for the excellent work that it had carried on and expressed the desire for more data to establish the probable limits of chimney effect which would assist the designer in making more accurate calculations of heating requirements.

W. H. Driscoll questioned whether the research work would influence the designing engineer to alter his methods of calculation of pipe sizes and heating requirements and stressed the importance of having greater knowledge of the minimum heating requirements under different conditions of wind, sun, and weather. He suggested that the study indicated further consideration of improving operating methods to effect the greatest economy.

Mr. Houghten gave a brief closure.

Resolutions

At the conclusion of the technical program, W. H. Driscoll presented the following resolutions, which were unanimously adopted.

BE IT RESOLVED, that the thanks and appreciation of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS assembled in Semi-Annual Meeting be expressed:

To the Philadelphia Chapter, for the friendly hospitality extended by each of its members and more especially by the Committee on Arrangements, whose efforts have again resulted in a never to be forgotten meeting of the Society.

To the Management of The Inn and its staff, whose cooperation and interest have added to the comfort and enjoyment of members and guests.

To the Daily Press and the Trade Papers, for the publicity given this Semi-Annual Meeting and the work of the Society and for the attendance of individual members.

To the Authors of Papers, in appreciation of the time spent in the preparation and presentation of important data on subjects of current interest.

New Officers Elected by N. D. H. A.

During the 27th annual convention of the *National District Heating Association,* held at the Pantlind Hotel, Grand Rapids, Mich., June 16-19, M. D. Engle, Boston, Mass., was elected president and W. H. Sanford, Philadelphia, Pa., was made secretary. The sessions were attended by over 200 operators, owners and managers of district heating plants in the United States and 25 manufacturers arranged an exhibit. At the sessions, discussions were led by the following committee chairmen: D. S. Boyden, R. M. Nee, S. S. Sanford, L. S. Phillips, R. J. J. Tennant, F. L. Witsell, A. D. Leach, H. C. Kimbrough, G. D. Winans, W. W. Stevenson, A. R. Mumford, G. K. Saurwein, Harold Farmer, J. M. Arthur, Jr., and L. S. Smith.

The report of the Commercial Relations Committee was given as well as talks on New Developments in Temperature Controls, the Relation of Building Occupancy to Steam Requirements, and Results of New Utilization Methods. Prof. F. R. Beitler, Ohio State University, discussed the subject of Orifice Metering and other speakers were L. D. Gray, N. O. Hayes, R. M. Nee, A. L. Dutton, R. G. Felger, G. C. Eaton, H. J. Bauer, Howard Goellner, A. A. Markson, Henry Kreisinger, R. E. Hall, M. A. Nelson, C. R. Erickson, R. Menke, J. M. Sperzel and G. C. Daniels.

Pleasant Days at Buck Hill

ONCE again the Committee on Arrangements of the Philadelphia Chapter upheld its reputation for entertaining A.S.H.V.E. members and guests in a royal manner, as hosts during the Society's Semi-Annual Meeting at The Inn, Buck Hill Falls, Pa., June 22-24. R. C. Bolsinger, General Chairman, assisted by W. F. Smith, Vice-Chairman, and other committee members was ready to welcome their guests, many of whom arrived on Sunday.

Registration in charge of H. G. Black began at 8:30 a. m., Monday, June 22, and following adjournment of the technical session, no time was lost in enjoying the opportunities for having a good time. At 1:30 p. m. the men golfers, including members and guests, played an 18-hole Kicker's Handicap on the Buck Hill Falls Course. Others enjoyed bowling on the green, tennis, and trout fishing.

Plans for the ladies were carried out under the leadership of Chairman M. C. Gillett and Miss Jane Louise Bolsinger acted as special hostess. During the early afternoon the ladies had a swimming party at the pool and at 4:00 o'clock they went to the Tennis Club where a reception and tea was given in honor of Mrs. G. L. Larson.

Beginning at 6:00 p. m. Monday evening almost everyone left for Skytop Mountain where a picnic and steak fry was enjoyed with members of *A.S.R.E.* Quantities of delicious food had been brought to the mountain top in preparation for the party and a number of the picnickers braved the cool air and lingered long enough to view the sunset and sing a few songs.

On Tuesday, following the joint technical session at The Inn, Council members of the A.S.H.V.E. and *A.S.R.E.* met for luncheon in the main dining room. Those present included W. H. Carrier, Newark, N. J., past president of both societies, and Pres. L. S. Morse, 1st Vice-Pres. H. M. Williams, 2nd Vice-Pres. Crosby Field, A. H. Baer, C. F. Holske, G. E. Hulse, C. R. Logan, Glenn Muffly, D. E. Perham, B. E. Seamon, J. L. Shrode, F. C. Stewart, and L. A. Tucker of the *A.S.R.E.;* Pres. G. L. Larson, 1st Vice-Pres. D. S. Boyden, 2nd Vice-Pres. E. H. Gurney, Treas. A. J. Offner, R. C. Bolsinger, S. H. Downs, W. L. Fleisher, Prof. C. M. Humphreys, Prof. F. E. Giesecke, J. F. McIntire, M. C. Beman, John Howatt, and W. A. Russell of the A.S.H.V.E.

Immediately following luncheon, those interested in golf played in the tournaments arranged for the Research Cup, the Philadelphia Chapter Cup, and 18-hole Medal Play over the Buck Hill Falls Course. At the same time arrangements were made for a sightseeing trip through the Poconos by H. H. Erickson, who was chairman of Publicity and Transportation, and horseback riding and outdoor shuffle board were also on the program.

On Tuesday morning the ladies could take their choice of a sightseeing trip, a swimming party, or an 18-hole Kicker's Handicap at the Buck Hill Falls Golf Course. From 12:30 to 1:30 they enjoyed a special luncheon at the Buck Hill Tennis Club when 68 were present. In the afternoon there were 11 tables of bridge and each table was provided with a white beaded bag and two decks of playing cards as prizes.

The Semi-Annual Banquet and Dance on Tuesday evening was one of the most enjoyable features of the meeting and was held in the main dining room of The Inn. M. F. Blankin, chairman of the Banquet Committee was toastmaster and presented the entertainment features. During dinner music was played by the Adelphia Orchestra, vocal selections were rendered by the Adelphia Quartet, and group singing was led by Christie, the accordionist.

All of the addresses were brief so as to provide more time for dancing and the program was featured by the presentation of the Past President's Memory Book to John Howatt, president of the Society during 1935, by S. R. Lewis, to which Mr. Howatt responded; the presentation of an Honorary Membership Certificate to Reginald Pelham Bolton by Mr. Howatt and Mr. Bolton's reply; a short address by Pres. G. L. Larson and a few words of greeting from John Cassell, the first president of Philadelphia Chapter.

W. P. Culbert, chairman of the Golf Committee, announced the winners in the various golf tournaments and with the aid of Col. W. A. Danielson, chairman of the A.S.H.V.E. Committee on Research, presentation of the Research Cup was made to R. T. Miller and Tom Brown, of Chicago, who had tied for first place. Mr. Culbert then announced the following winners of the Kicker's Handicap who selected their prizes: H. J. Carr, Drexel Hill, Pa., and Tom Brown, with tie scores, percolator and golf bag; J. H. Hucker, Norristown, Pa., sport bag; A. E. Kriebel, Berwyn, Pa., mix-master; G. H. Cummins, Detroit, J. F. McIntire, Detroit, A. T. Papineau, Boston, H. B. Hedges, Philadelphia, and R. P. Schoenijahn, Wilmington, Del., golf balls.

Those who received prizes in the ladies tournament were Mrs. H. C. Murphy, Louisville, Ky., cheese plate; Mrs. W. E. Heibel, Old Greenwich, Conn., bon bon dish; Miss Mary Driscoll and Miss Elizabeth Driscoll, Jersey City, N. J., and Mrs. M. F. Blankin, Philadelphia, golf balls.

Mr. Culbert spoke of one of the most popular Philadelphia members whose death occurred during the past year, and said that Philadelphia Chapter had offered a cup in memory of W. R. Eichberg, to be played for at Semi-Annual Meetings by members of Chapters, the award to be made on the basis of the three lowest scores turned in by members of one Chapter. The first presentation was made to G. E. Olsen, president of New York Chapter whose team had the lowest scores.

Others who received prizes were A. C. Grant, Minneapolis, hostess set; W. E. Voisinet, Buffalo, golf bag; R. T. Miller, Chicago, sport bag; M. F. Blankin, Philadelphia, sandwich toaster; A. S. Morphett, Winnetka, Ill., G. D. Guler, Philadelphia, W. J. Osborn, Fairfield, Conn., L. C. Davidson, Philadelphia, R. C. Bolsinger, Norristown, Pa., D. S. Boyden, Boston, N. P. Fenner, New York, and C. E. Price, Chicago, golf balls.

The scores:

18-Hole Tournament—Kicker's Handicap

Name	*Gross*	*Handicap*	*Net*
Carr, H. J.	101	20	81
Brown, Tom	92	11	81
Price, C. E.	95	23	72
Rietz, E. W.	102	25	77
Hedges, H. B.	122	25	97
Hucker, J. H.	100	20	80
Osborn, W. J.	92	14	78
Culbert, W. P.	89	10	79
Driscoll, W. H.	103	24	79
Smith, W. F.	98	20	78
Fenner, N. P.	93	15	78
Bolsinger, R. C.	98	10	88
Farnham, R.	127	40	87
Elliott, P. F.	111	40	74
Leonhard, L. W.	146	40	106
Dever, H. F.	106	21	85
Guler, G. D.	102	27	75
Grant, A. C.	105	28	77
McElgin, John	127	30	97
Hutchins, W. H.	105	28	77
Hutzel, H. F.	114	25	89
May, M. F.	95	17	78
Knapp, A. E.	97	17	80
McIntire, J. F.	101	19	82
Moore, R. E.	99	12	87
McDonnell, E. N.	94	21	73
Hunter, L. N.	102	17	85
Blankin, M. F.	86	8	78
Boyden, D. S.	99	21	78
Adams, N. D.	107	30	77
Matchett, J. C.	107	22	85
Webster, W., Jr.	95	17	78

18-Hole Tournament—Kicker's Handicap (Continued)

Name	Gross	Handicap	Net
Van Alsburg, J. H.	121	36	85
Duysters, R. F.	118	32	86
Harding, L. A.	122	25	97
Carrier, W. H.	109	25	84
Beman, M. C.	117	30	87
Voisinet, W. E.	86	0	86
Kriebel, A. E.	125	45	80
Erickson, H. H.	112	35	77
Holmes, P. B.	123	40	83
Ahlff, A. A.	92	16	76
Wagner, E. A.	118	40	78
Olsen, G. E.	105	21	84
Timmis, W. W.	109	25	84
Carpenter, R. H.	117	36	81
Daly, R. E.	96	9	87
Soule, L. C.	106	30	76
Chester, T.	109	32	77
Barr, G. W.	95	20	75
Cummins, G. H.	111	31	80
Morphett, A. S.	97	19	78
Durkee, M. E.	124	35	89
Eastman, C. B.	107	20	87
Brigham, C. M.	98	20	78
Plum, L. H.	136	50	86
Hynes, L. P.	134	40	94
Schoenijahn, R. P.	151	50	101
Binder, C. G.	137	50	87
Papineau, A. T.	89	7	82

18-Hole Tournament—Research Cup and W. Roy Eichberg Memorial Cup

Name	Gross	Handicap	Net
Grant, A. C.	100	28	72
Scanlon, E. S.	121	30	91
Osborn, W. J.	89	14	75
Webster, W., Jr.	102	18	84
Morphett, A. S.	93	19	74
Brigham, C. M.	99	18	81
Haynes, C. V.	106	22	84
Stacey, A. E., Jr.	115	27	88
Barr, G. W.	101	20	81
Fleisher, W. L.	104	22	82
Thornton, R. T.	105	18	87
Hedges, H. B.	117	25	92
Fenner, N. P.	91	15	76
Price, C. E.	120	20	100
Rietz, E. W.	105	19	86
Nesbitt, A. J.	108	20	88
Adams, N. D.	102	20	82
Smith, W. F.	104	18	86
Davidson, L. C.	90	15	75
Durkee, M. E.	129	27	102
Eastman, C. B.	118	25	93
Harding, W.	128	27	101
Heibel, W. E.	125	30	95
Driscoll, W. H.	105	26	79
Timmis, W. W.	105	26	79
Papineau, A. T.	89	11	78
Boyden, D. S.	100	24	76
Moore, R. E.	97	16	81
Erickson, H. H.	110	28	82
Hucker, J. H.	116	18	98
Kriebel, A. E.	116	30	86
Bolsinger, R. C.	90	15	75
Lyons, F. E.	132	30	102
Coombs, H. W.	109	30	79
Soule, L. C.	104	26	78
May, M. F.	103	17	86
McIntire, J. F.	104	23	81
Olsen, G. E.	103	21	82
Mytinger, K. L.	147	30	117
Hutzel, H. F.	110	25	85
McGaughey, H. M.	135	30	105
Plum, L. H.	137	30	107
Binder, C. G.	145	30	115
Hynes, L. P.	140	30	110
Schoenijahn, R. P.	136	30	106
Fahnestock, M. K.	119	30	81
Van Alsburg, J. H.	126	30	96
Close, P. D.	127	30	97
Rodee, E. J.	137	30	107
Gurney, E. H.	101	20	81
Ahlff, A. A.	91	16	75
Beman, M. C.	119	30	89
McElgin, John	121	30	91
Guler, G. D.	102	27	75
Donkersley, A. B.	103	25	78
Novotney, T. A.	117	30	81
Voisinet, W. E.	86	8	78
Holmes, P. B.	129	30	99
McDonnell, E. N.	97	20	77
Hunter, L. N.	112	22	90
Dockeray, F. A.	113	20	93
Blankin, M. F.	89	15	74
Randall, W. C.	116	30	86
Lloyd, E. C.	122	30	92
Miller, R. T.	97	25	72
Dever, H. F.	109	27	82
Kingsland, G. D.	112	30	82
Chester, T.	112	30	82
Evans, E. C.	113	30	83
Brown, Tom	87	15	72
Kingswell, W. E.	146	30	116

Ladies Tournament

Name	Gross	Handicap	Net
Murphy, Mrs. H. C.	105	20	85
Driscoll, Miss Elizabeth	108	33	75
Driscoll, Miss Mary	113	32	81
Heibel, Mrs. W. E.	153	45	108
Blankin, Mrs. M. F.	121	40	81

At the close of the final technical session, June 24, some of the members and guests remained at The Inn and continued to enjoy the golfing, bowling, swimming, and the cool mountain breezes.

Two meetings of the Council were held on Sunday, June 21, and on Wednesday, June 24. A luncheon and meeting of the Committee on Research occurred on June 22, a breakfast meeting of the Nominating Committee took place on June 23, and the Guide Publication Committee had a luncheon and meeting.

L. P. Hynes was chairman of the committee responsible for the financial success of the meeting.

It is believed that the Buck Hill Falls meeting was attended by the largest number of representatives of the second and third generation of A.S.H.V.E. members than on any previous occasion and the attractive group of young people gave every evidence of thoroughly enjoying themselves. Among them were the Misses Jane Bolsinger, Collingswood, N. J., Ruth L. Carpenter, White Plains, N. Y., Elizabeth A. Driscoll and Mary J. Driscoll, Jersey City, N. J., Linda Geren, Ft. Worth, Tex., Peggy Haynes, Ardmore, Pa., Jane Hedges, Plainfield, N. J., Linda Hodges, Yoakum, Tex., Dorothy A. Larson, Madison, Wis., Roberta H. Schoenijahn, Wilmington, Del., and Messrs. Cecil S. Farrar, Buffalo, N. Y., Robert Hedges, Plainfield, N. J., Richard A. Houghten, Pittsburgh, Pa., John Hucker, Norristown, Pa., Foster Larson, Madison, Wis., William Matchett, Chicago, Ill., Bobby Murphy, Louisville, Ky., Robert Severns and William H. Severns, Jr., Urbana, Ill., and Morley Walker, Detroit, Mich.

Everyone who attended has happy recollections of the days spent at The Inn, Buck Hill Falls, Pa., and the Society's Semi-Annual Meeting 1936 was voted one of the most successful and enjoyable on record.

The Committee on Arrangements was deluged with congratulations for their fine work: R. C. Bolsinger, *General Chairman;* W. F. Smith, *Vice-Chairman;* H. G. Black, *Registration;* J. H. Hucker, *Entertainment;* W. P. Culbert, *Golf;* M. F. Blankin, *Banquet;* M. C. Gillett, *Ladies;* L. P. Hynes, *Finance;* H. H. Erickson, *Publicity and Transportation;* and Miss Jane Louise Bolsinger, *Hostess.*

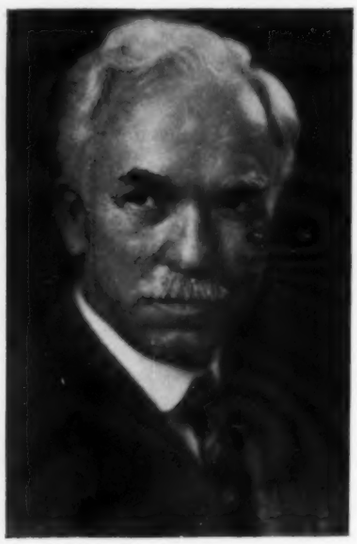
Carrier Air Conditioning School

Recently 57 young graduates of accredited engineering schools completed a course of training in the Air Conditioning School conducted by Carrier Engineering Corp., Newark, N. J. The instruction covered phases of air conditioning engineering, application, and installation and upon completing final examinations, these men were added to headquarter departments and to district offices and local installation organizations throughout the country.

O. P. Hood Completes Quarter Century of Service

Dr. O. P. Hood, chief of the Technologic Branch and chief engineer of the Mechanical Division of the U. S. Bureau of Mines, Department of the Interior, retired on June 30, following 25 years of service with the Bureau. A farewell luncheon attended by more than 100 associates and former associates from the Bureau of Mines and from technical and scientific societies, in which he has been active, was given at the Hotel Harrington, Washington, D. C., June 27. Director J. W. Finch and two former directors of the Bureau, H. Foster Bain and F. G. Cottrell, and several others, made addresses. Various tokens of appreciation were presented to Dr. Hood.

Ozni Porter Hood, the son of an inventor, was born in Lowell, Mass., on June 14, 1865, was educated in mechanical engineering



O. P. Hood

in Worcester and Rose Polytechnic Institutes, and served as professor of mechanical engineering, first at Kansas Agricultural College and then at the Michigan College of Mines.

Dr. Hood joined the Bureau of Mines at its Pittsburgh Experiment Station in 1911. He took charge of the fuel investigations which had been started in 1904 at the World's Fair in St. Louis and continued by the U. S. Geological Survey prior to the formation of the Bureau of Mines on July 1, 1910. He coordinated this work and developed mechanical and electrical engineering research pertaining to safety in mines. He organized a system for testing and approving, with respect to safety and efficiency, electrical equipment for use in gassy coal mines. Present-day mechanization of coal mines could not have been accomplished without anticipating this trend and preparing for it. He organized and directed instrument and machine shops in which the crude ideas of chemists and physicists evoluted into smoothly functioning instruments of precision. The Davis multiple-unit calorimeter, the Burrell gas detector, and the Gibbs oxygen breathing apparatus are early examples of his mechanical genius. He made a pioneering study of gasoline mine locomotives in relation to safety and health, which later induced Chief Engineer Holland, designer of the famous Holland Tunnel under the Hudson River, to seek the Bureau's cooperation in studying the problems of ventilating this tunnel.

In addition to the many administrative duties of the chief of a major division in the Bureau, Dr. Hood found time to plan and direct the design of the new building for the Pittsburgh Experiment Station. This building, completed in 1918, remains today an outstanding tribute to his genius in carrying out the wishes of Dr. J. A. Holmes, first director of the Bureau, who envisioned a great experiment station for the mineral industries where fundamentals for improving health and safety could be studied, and scientific problems in the conservation of mineral resources and the more efficient utilization of mineral products could be worked out. This vision called for well-designed and adequately equipped scientific and engineering laboratories, and although Dr. Holmes did not live to see his vision realized, Dr. Hood carried out his dream.

Since 1919 when the A. S. H. V. E. Research Laboratory was established it has been housed in this Bureau of Mines Building and the cooperative research work that has been carried on has had Dr. Hood's active encouragement and support as well as his unfailing interest.

Following the completion of the station in 1918, Dr. Hood was called to the Washington Office in order to meet widespread demands on the Bureau in the field of fuels and mechanical equipment. Here, with G. S. Rice in mining, C. L. Parsons in chemistry, F. G. Cottrell in metallurgy, C. L. Naramore in petroleum, and D. A. Lyon in experiment stations administration, he did his part in expanding the Bureau's services after the World War.

With his co-workers in the mechanical division, he continued the Bureau's fundamental research on the mechanism of combustion in fuel beds and participated in the practical development of the combustion of powdered coal; he initiated timely studies on the gasification of coal, and designed and built a simple unit for carbonizing lignite.

He directed smoke abatement investigations in various cities and advised the District of Columbia Government and other cities on methods of smoke abatement. He has carried out nation-wide sampling of coal and its analysis in connection with Government purchase of coal on specifications, and has made very substantial savings in the production of heat and power in Government plants.

In 1926 Dr. Hood again responded to the needs of the Bureau in accepting the additional duties of Chief of the Technologic Branch. To this position he brought a wealth of experience and a maturity of judgment which helped carry the Bureau through a trying period. Although continuing to direct his divisional work, he gave thought to the program of each division and was a valued counsellor to the directors on questions of policy as well as technology. His method of revolving problems into their fundamentals, his understanding of men and motives, and his appreciation of relative values were helpful in many ways. Although a firm supporter of scientific research he believed that Bureau activities should be directed toward useful objectives and along the lines of the Bureau's organic act.

His retirement completes a quarter century of service in which he has helped to guide the Bureau of Mines from infancy to maturity. His fine administrative record, as well as his technical achievements, won for him a high position in his profession. He was made an Honorary Member of the American Society of Heating and Ventilating Engineers in 1929, and has served as ex-officio member of the Society's Committee on Research. He became a life member of the *American Society of Mechanical Engineers* in 1935, and in 1932 his Alma Mater, Rose Polytechnic Institute, conferred on him the honorary degree of Doctor of Engineering.

A.S.T.M. Elects Officers

At the annual meeting of the *American Society for Testing Materials,* A. C. Fieldner, chief engineer, Experiment Stations Division, U. S. Bureau of Mines, Washington, D. C., was elected president.

Mr. Fieldner is well known to members of the A.S.H.V.E. through his work at the Bureau of Mines and as co-author of Ventilation of Vehicular Tunnels, a Report of the U. S. Bureau of Mines to New York State Bridge and Tunnel Commission and New Jersey Interstate Bridge and Tunnel Commission, published in the A.S.H.V.E. Journal, during 1926. Following

his graduation in chemical engineering from Ohio State University in 1906, and a short apprenticeship with the Denver Gas and Electric Co., Mr. Fieldner became fuels chemist in the U. S. Geological Survey at Pittsburgh, Pa. In 1910, when this work was transferred to the newly created Bureau of Mines, he was placed in charge of the fuels chemical laboratory and later of the gas investigations laboratory also. During the war he was in charge of the Gas Mask Section, Chemical Warfare Service. He returned as supervising chemist of the Pittsburgh Station, and in 1921 was placed in charge of the station. In 1925 he was appointed chief chemist of the Bureau of Mines, and in 1927 was placed in administrative charge of the Bureau's Experiment Stations Division, with headquarters in Washington, D. C.

Other officers elected to serve *A.S.T.M.*, were T. G. Delbridge, Philadelphia, Pa., vice-president; and the following as members of the Executive Committee to serve a term of two years—O. U. Cook, Birmingham, Ala., H. F. Gonnerman, Chicago, Ill., C. S. Reeve, Leonia, N. J., F. E. Richart, Urbana Ill., and F. M. Waring, Altoona, Pa.

Minnesota Chapter Elects Officers and Enjoys Golf

May 11, 1936. The final meeting of the 1935-36 season was held by Minnesota Chapter at the Golden Valley Country Club, and 16 golfers teed off shortly after 2:00 p. m.

F. H. Schernbeck, chairman of the Entertainment Committee, and A. J. Huch awarded a number of prizes to the holders of low scores.

Dinner, with 35 members present, election of officers, and entertainment followed the afternoon's golf.

Secy. R. E. Backstrom was instructed to cast a unanimous ballot for the recommendations of the Nominating Committee, submitted by Chairman A. B. Algren, as follows:

President—N. D. Adams
Vice-President—R. E. Backstrom
Secretary Treasurer—J. E. Swenson
Board of Governors—G. C. Morgan, R. C. Jordan.

April 13, 1936. Pres. C. E. Gausman called the meeting to order at the Minnesota Union and the minutes of the previous meeting were read and approved. Forty-two members and guests attended.

Secy. R. E. Backstrom read a letter from I. O. Friswold, director of buildings and business administration, Department of Education, State of Minnesota, requesting the Chapter to appoint a committee of five members to assist the Department of Education in revising its requirements relating to the heating and ventilation of public school buildings. It was moved by Prof. F. B. Rowley, seconded by H. E. Gerrish, and carried that the chair appoint such a committee.

A letter from G. A. Wegner invited members of Minnesota Chapter to attend a talk by D. D. Wile, chief engineer on refrigeration and air conditioning control equipment, Detroit Lubricator Co., to be given at Dunwoody Institute.

H. E. Gerrish, chairman of the Membership Committee, submitted the slate of officers for election at the May meeting.

Prof. Frederick Bass, University of Minnesota, consulting engineer for the Minneapolis-St. Paul Sanitary District, was the evening's principal speaker. Professor Bass traced the history of the present sewage disposal system and as a point of interest he mentioned that Dr. Folwell was perhaps the first to propose such a system for the Twin Cities. It took approximately 50 years for that proposal to become a reality, for in 1933 the first contract for the joint system, to cost approximately $20,000,000 when completed, was let, and all contracts including the settling basins are to be completed by 1937. It is estimated that this system will be adequate for the Twin Cities until 1980.

Professor Bass illustrated his talk with lantern slides and gave an interesting discussion, answering a number of questions at the close of the meeting.

Pacific Northwest Chapter Elects Officers and Plans Picnic

May 26, 1936. The final spring meeting of Pacific Northwest Chapter was held at the Hungerford Hotel, Seattle, Wash., with dinner at 6:15 p. m. Thirty-eight members and guests attended and the business session was called to order at 7:30 with the reading of the minutes of the March and April meetings.

The action of the Society's Council regarding limited chapter membership was discussed with the result that the members and friends of the Pacific Northwest Chapter will cooperate with the Council's ruling discontinuing limited memberships.

The Relative Efficiencies of Control Systems as Applied to Oil Burners and Boilers was presented by George Semple and a brief discussion followed.

Then Foss Godfrey discussed A Commercial Development of Atomic Energy and explained its application to the treatment of domestic and boiler waters for the elimination of scale and corrosion.

The results of the election were announced and the following officers were unanimously chosen to serve for the year 1936-37:

President—S. D. Peterson
Vice-President—W. W. Cox
Secretary—D. C. Griffin
Treasurer—M. J. Hauan

Lincoln Bouillon, retiring president, turned the chair over to President Peterson and the new officers accepted their election.

A picnic committee was appointed by President Peterson consisting of Messrs. R. O. Boyker, M. N. Musgrave, and Langdon, before the meeting adjourned at 9:45 p. m.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 19 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Coun-

cil, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by August 15, 1936, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Bradford, G. G., Repr., Frick Co., Shanghai, China.	R. T. Thornton E. E. Johnson	C. C. Cheyney Roswell Farnham
Cullen, A. G., Executive, Cullen, Inc., Washington, D. C.	W. A. Danielson T. H. Urdahl	L. F. Nordine C. F. Ritt
Davis, G. C., Sales Engr., Northern Public Service Corp., Winnipeg, Man., Can.	C. H. Turland Frank Thompson	J. B. Steele William Glass
Fenner, E. M., Engr., Staples Coal Co., Fall River, Mass. (*Reinstatement and Advancement*)	J. D. McLaughlin E. W. Gibbs	J. C. Hartwell J. B. Coleman
Figgis, T. G., Mgr. Air Cond. & Refrg. Dept., Malcolm & Co., Ltd., Shanghai, China.	Doctor Carter H. W. Hart-Baker	C. B. Morrison C. J. Doughty
Friedman, D. H., Jr., Air Cond. Engr., Miami Beach, Fla.	W. E. Stark L. C. Harvey	C. K. Lingo S. G. Pizie
Hahn, R. F., Sales Engr., Frigidaire Corp., Atlanta, Ga.	H. W. Moore L. L. Kuempel	W. J. McKinney E. E. Bocock (*Non-Member*)
Hamlet, F. A., Mgr., C. A. Dunham Co., Ltd., Montreal, Que., Can.	G. L. Wiggs Leo Garneau	F. G. Phipps F. J. Friedman
Hitt, J. C., Br. Mgr., Holland Furnace Co., Wheeling, W. Va.	K. R. Dorries (*Non-Member*) F. J. Fuller (*Non-Member*)	H. B. Humphries (*Non-Member*) C. G. McAndrews (*Non-Member*)
Kinney, A. M., Pres., A. M. Kinney, Inc., Cincinnati, Ohio.	W. A. Danielson James Coombe	K. A. Wright L. G. Powers
Larson, C. W., Service Engr., Barnes & Jones, Inc., Jamaica Plain, Mass.	G. L. Larson W. E. Barnes	W. T. Jones N. J. H. Shaw
Robertson, J. A. M., Vice Pres., The James Robertson Co., Ltd., Montreal, Que., Can.	G. L. Wiggs C. W. Johnson	F. J. Friedman F. G. Phipps
Roche, I. V., Prov. Mgr., Fess Oil Burners of Canada, Ltd., Montreal, Que., Can.	G. L. Wiggs G. H. Osborne	C. W. Johnson F. J. Friedman
Rowe, I. E., Shop Foreman & Estimator, Etie Sheet Metal Works, Houston, Texas.	J. A. Kiesling L. C. Way (*A.S.R.E.*)	J. A. Rollosson (*Non-Member*) N. C. Way (*Non-Member*)
Sickert, G. D., Acting Mgr. Htg. Div., Perfex Radiator Corp., Milwaukee, Wis.	L. A. Burch G. L. Larson	D. W. Nelson R. W. Wilson (*Non-Member*)
Stermer, C. J., Engr., Crane Co., Chicago, Ill.	A. P. Kratz M. K. Fahnestock	W. H. Baker, Jr. J. P. Magos (*Non-Member*)
Watkins, G. B., Director of Research, Libbey-Owens-Ford Glass Co., Toledo, Ohio.	D. H. Goodwillie (*Non-Member*) H. H. Baker (*Non-Member*)	C. D. Haven (*Non-Member*) C. E. Husted (*Non-Member*)
World, H. P., Mech. & Structural Designer, Mackenzie Waters, Toronto, Ont., Can.	M. W. Shears A. J. Dickey	G. A. Playfair H. R. Roth
Young, F. H., Jr., Mgr., Young Heat Engrg. Co., Billings, Mont.	L. B. Miller H. F. Dever	C. C. Cohagen G. D. Kingsland

Candidates Elected

In past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

Beling, E. H., Owner & Chief Engr., The Beling Engrg. Co., Moline, Ill. (*Advancement*)

Harding, E. R., Br. Mgr., Kewanee Boiler Corp., Greensboro, N. C.

Kroeker, J. D., Pres., Columbia Engrg. Co., Portland, Ore.

Lange, R. T., Engr., Hartzell Propeller Fan Co., Piqua, Ohio.

Walsh, E. R., Jr., Mgr. Retail Sales, Gilbert & Barker Mfg. Co., Springfield, Mass. (*Advancement*)

ASSOCIATES

Gittleson, Harold, Sales Mgr., Lariviere, Inc., Montreal, Que., Can.

Iverson, H. R., Engrg. & Sales, The Trane Co., Washington, D. C.

Lenihan, W. O., Owner, W. O. Lenihan, Inc., Buffalo, N. Y.

JUNIOR

Rowe, W. M., Sales, American Blower Corp., Cleveland, Ohio.

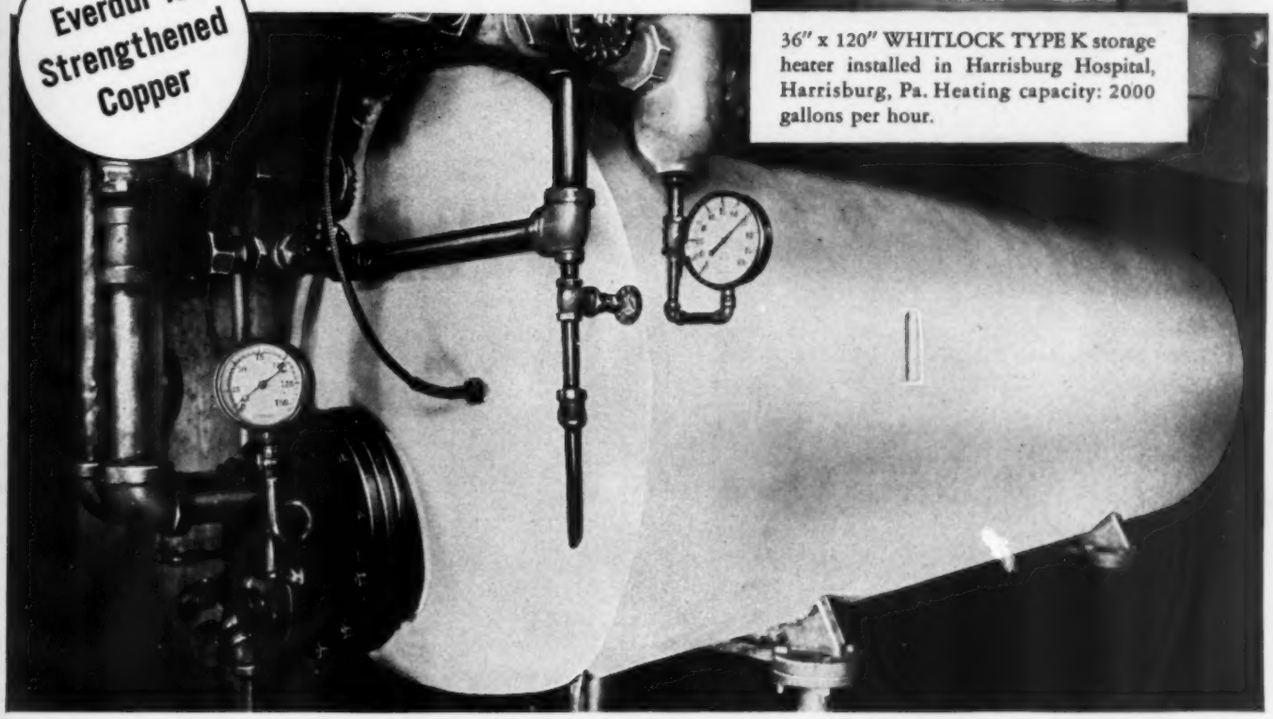
This Hospital had to have

CLEAN, RUST-FREE WATER

...so a heater of rust-proof *EVERDUR METAL was installed

36" x 120" WHITLOCK TYPE K storage heater installed in Harrisburg Hospital, Harrisburg, Pa. Heating capacity: 2000 gallons per hour.

★ Everdur is Strengthened Copper



NO hospital can afford to be without clean, *rust-free* hot water. And to assure an abundance of this vital necessity at all times, the Harrisburg Hospital, Harrisburg, Pa., installed a storage heater of non-rust Everdur Metal.

Lowered maintenance costs will result from this installation. For Everdur *cannot* rust. A storage heater made of this durable, rustless metal protects owners against all repair and replacement due to rust . . . gives dependable, trouble-free service indefinitely. Everdur is a rugged, copper-silicon alloy which possesses remarkable corrosion-resistance and exceptionally high strength It is readily welded by all usual methods...and is made in all commercial shapes including tank plates which conform to all requirements of A.S.T.M. specification B96-36T. Additional data on Everdur Metal mailed on request. 36139

EVERDUR METAL—"Everdur" is a registered trade-mark identifying products of The American Brass Company made from alloys of copper, silicon and other elements.

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EVERDUR METAL *for* TANKS

A COPPER HIGH-STRENGTH ALLOY

for economical and efficient space heating

Fifty years of manufacturing experience are incorporated in this new TRANE Standard Unit Heater just announced. Here are a few of its outstanding features.

Floor Line Spread—A built-in feature that puts heat down to the floor where you want it. Eliminates wasted heat at the ceiling. Exclusively TRANE.

Efficient Heating Element — Built without solder. Guaranteed for pressures to 150 pounds. Stands hardest service.

Quiet Operation—Scientifically designed and balanced fan. Eliminates noise and increases distance the air can be thrown.

Attractive Appearance—Smooth corners. Soft brown finish. Trim and compact. At home in the office as well as the factory.

Heavy Construction—Casings made of 18 gauge metal for durability. Eliminates vibration.

Many Sizes—Sixty sizes—meet all requirements. The most complete line of units on the market.

ANNOUNCEMENT OF UNUSUAL INTEREST

THE NEXT ISSUE OF THIS PUBLICATION WILL CARRY AN INTERESTING ANNOUNCEMENT OF AN UNUSUAL DEVELOPMENT IN UNIT HEATERS FOR THE 1936 MARKET. A REQUEST ON YOUR LETTERHEAD WILL BRING ADVANCE INFORMATION.

THE TRANE COMPANY

Mfrs. of Heating, Ventilating and Air Conditioning Equipment.

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TRANE

Booklets, Reports and Papers

Operation of Building Heating Systems

R. E. Hieronymus, of Aldis & Co., Chicago, chairman of the National Association of Building Owners and Managers operating methods and devices committee, discussed the operation of office building heating systems at the Association's recent annual convention at Dallas. Because a heating system must be designed for the coldest weather likely to be encountered, he said that for about 95 per cent of the time it must operate at less than its maximum rating, which indicates the great necessity of proper control. He classified the types of office building heating systems as one pipe steam, two pipe steam (usually associated with the use of vacuum), and hot water, the latter increasing in popularity because it can be combined with a summer cooling system, and in summer or winter a wide range of temperature of the circulating medium may be maintained.

Economy in the purchase and use of fuel is of major importance, he stated, for, neglecting payroll and after the bill for electricity, fuel is the largest single commodity purchased by many buildings. He disposed of the subject of coal by saying that any building using in excess of 150 to 200 tons annually, almost regardless of the type and cost of fuel burned at present, should be equipped with stokers and with a device to prevent excessive draft over the fire. In his experience he has found that for fully automatic, efficient combustion, a competent fireman should be in attendance; also that after installation of stokers, notwithstanding considerable improvement the first year, further improvement is achieved each year up to about four years. Pulverized coal, oil, gas, electricity and district steam were given brief attention.

A chart for the Brooks Building, Chicago, showing a reduction in cost of fuel per degree day from 77c with hand-fired boilers to 41c was presented, major part of this reduction being due to stokers, plus more economical utilization of steam.

The use of the "Erlenborn Chart"—a monthly sheet showing daily average temperatures and daily fuel or steam consumption—in obtaining operating economy was described, and examples of results achieved given. In two years, one building decreased fuel consumption 26.7 per cent despite rising occupancy. Waste of fuel because of too high temperatures, open windows, etc., was given attention, and the advisability of checking temperatures throughout the building with portable recording thermometers was stressed. Economy in the boiler room was discussed, and the value of using CO_2 meters, particularly the recording type, mentioned.

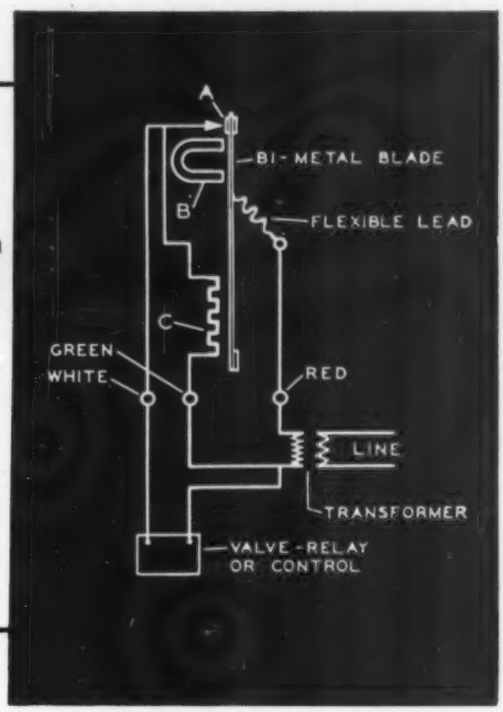
The chief engineer or operating superintendent should have a late edition of "Air Conditioning for Comfort," by Lewis; "Heating and Ventilating," by Allen and Walker; the A.S.H.V.E. "Guide"; the "Handbook" of the N.D.H.A., and the N.D.H.A. booklet "Principles of Economical Heating," Mr. Hieronymus said. In conclusion he stated that *if you need a thing, you pay for it whether you get it or not,* whether it be CO_2 instruments, control equipment, a "6 in. shelf" of good handbooks, etc.

Utility's Position in Air Conditioning

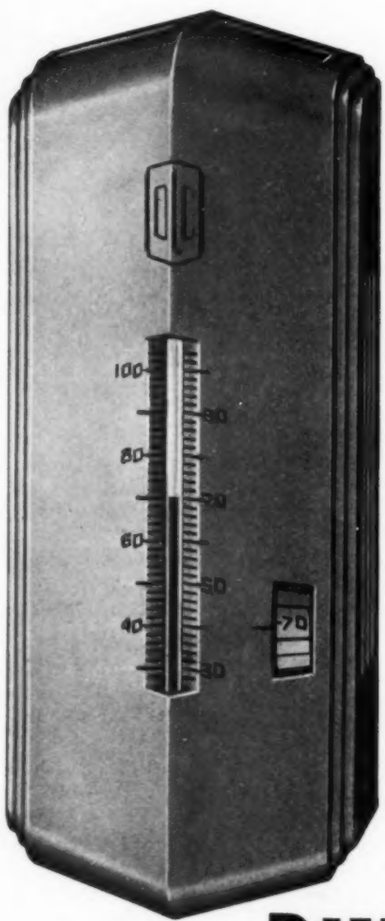
The utility's position in the air conditioning field was reviewed by C. E. Michel of the Union Electric Light & Power Co., chairman of the Edison Electric Institute's air conditioning committee, at the Institute's annual meeting at St. Louis in June. Pointing out that there are few modern developments that touch

[1]Editor's Note—"Air Conditioning for Comfort," by Lewis, published by Keeney Publishing Co., 6 N. Michigan Ave., Chicago, Ill. "Heating and Ventilating," by Allen and Walker, published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. A.S.H.V.E. "Guide," published by American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York, N. Y. N.D.H.A. "Handbook" and "Principles of Economical Heating," published by National District Heating Association, 1317 Spruce St., Philadelphia, Pa.

COMPENSATION ENTIRELY INDEPENDENT *of electrical load on thermostat*



Circuit of the Two-Eleven Compensated Thermostat showing Heater Element connected in PARALLEL with main circuit—an Exclusive feature.



● The small heater element in the "Genuine Detroit" Compensated Two-Eleven is operated in parallel with the main circuit through the Thermostat. Consequently fluctuations in electrical load can have no effect on the action of the pre-heater—nor on its accurate control of differential. This is an important factor in attaining straight line temperature control and an exclusive feature of the Two-Eleven.

Also, because the heater element is readily adjustable, the Two-Eleven can be used for any load without changes or replacement of any element. This means that you stock only one type for all 20-25 volt circuits.

Adjustment of the small heater element is easily made to satisfy any local requirements—type of exposure, kind of construction or type of heating plant. Radical changes in temperature have no effect on its accurate straight line temperature control.

The Two-Eleven is a masterpiece of engineering design beautifully finished to harmonize with artistic interiors. It is supplied with or without heat compensation—both types in all models for heating, cooling, night and day, summer and winter and three wire.

Write for Bulletin 86.

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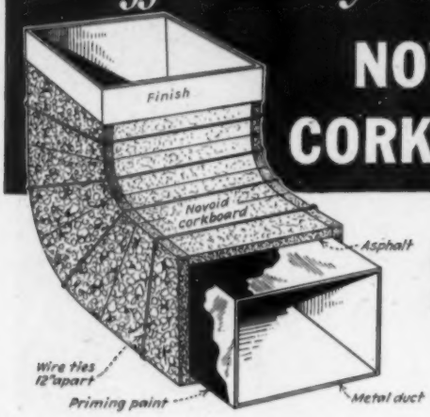
For permanent air-conditioning efficiency—use

NOVOID CORKBOARD



THE NATURAL HEAT BARRIER FOR SQUARE AND RECTANGULAR DUCTS

EFFICIENT and economical air-conditioning calls for adequate insulation of cool air ducts and other parts of the system. That's why so many leading engineers and heating contractors specify Novoid Corkboard Insulation.

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the interests of the utility in as many ways as does air conditioning, he stated that not only does promotion of air conditioning business open up a broad new field for the sale of energy, but enables the utility to render a service to its customers which earns an unusually high degree of appreciation, for it is a service that is most welcome and valuable to the customer.

In the experience of every utility there exist precedents that can be utilized in the promotion of air conditioning, said Mr. Michel, which has leapt into public favor so suddenly as to take even the most optimistic by surprise. He said that his own company's confidence has been rewarded, for during the previous twelve months, more than 5000 kilowatts of air conditioning load has been picked up, in a period when 5000 kw loads were not any too common.

Among the advantages of summer air conditioning from the utility's standpoint is that it does not supplant some less effective means to the same end, but that it is a new service to humanity. It is practical and proven, using long established principles, as ventilation and air circulation are old arts; air cleansing and humidification are familiar processes; heating problems are thoroughly understood. Air conditioning applies these fundamentals in a new way.

Mr. Michel devoted attention to the various methods by which a utility can promote air conditioning business, local conditions determining the extent of utility promotion and sales activities. He stressed that promotion is a twelve months' activity because during the winter the architect and engineer have more time to consider air conditioning problems than they have during the summer months, and prospective owners are interested in looking over equipment prior to the spring building period. He concluded by stressing the importance of a thorough knowledge of the mechanics of air conditioning.

Coal Friability Tests

"Coal Friability Tests—A Comparative Study of Methods for Determining the Friability of Coal and Suggestions for Tumbler and Drop Shatter Test Methods," by R. E. Gilmore, J. H. H. Nicolls, and G. P. Connell, Department of Mines, Ottawa, Canada. 102 *pp.*, 4 *plates*, 6½x9½ *in., paper bound. Price,* 25c.

Reports of friability (or the readiness of coal to crumble or break into smaller pieces) tests conducted at the Fuel Research Laboratories of the Department of Mines at Ottawa during 1932, '33, and '34 are given. These tests had the dual objective of developing a method for testing the comparative handling properties of ton-lot samples of coal incident to an investigation of coals from Canadian collieries, and also of comparing different laboratory friability methods in connection with the program of the A.S.T.M. committee on coal and coke, R. E. Gilmore being chairman of the sub-committee on friability.

Following the preface and review by Gilmore, comparison and interrelation of methods for the determination of friabilities of coals are discussed by Nicolls, and supplementary shatter tests by Connell. The appendices are devoted to the tumbler test and the drop shatter test.

Standards for Rotating Electrical Machinery

"American Standards for Rotating Electrical Machinery," published by the American Standards Association, 29 *W.* 39th *St., New York, N. Y.* 97 *pp.*, 8x10½ *in., paper cover. Price,* $1.30.

New and revised requirements for most of the rotating electrical machinery manufactured and used in the United States is made available in this one volume. Standard requirements and specifications for electrical machinery, from large central station generators and industrial motors to the small motors used on household appliances, are included. Direct current, synchronous, and induction machines, sychronous converters, and a-c and d-c fractional hp motors are covered.

The standards offer the advantage of a limited variety of well chosen ratings and types from which a motor or generator may be selected which is suitable for practically any ordinary purpose.

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Use NATIONAL Copper-Steel Pipe wherever atmospheric corrosion is troublesome and watch your maintenance bills go down. This longer lasting pipe costs only a little more, but the extra years of service it insures amply justify its choice. More than 20 years of actual use in all types of service have proved its lasting qualities.

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(At Right) **NON-COPPER PIPE** showing effect of atmospheric corrosion (after seven years) in moist mill atmosphere.

(At Left) **COPPER-BEARING PIPE** showing little or no effect after years of service in the same corrosive atmosphere.

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Book Reviews

Technical Drawing

"Technical Drawing," by Frederick E. Giesecke, Director of the Texas Engineering Experiment Station and College Architect, Alva Mitchell, Professor of Engineering Drawing, and Henry C. Spencer, Assistant Professor of Engineering Drawing, all of the Agricultural and Mechanical College of Texas. Published by The Macmillan Co., 60 Fifth Ave., New York, N. Y. 564 + xii pp., 6 x 9 in., clothbound. Price, $3.00.

This is a most excellent text for both reference and classroom use, being a comprehensive and up-to-date treatment of the subject illustrated with some 850 drawings and sketches and including more than 350 problems.

Following the introductory chapter, the subjects covered are instruments and materials, geometry of technical drawing, lettering, projections, multi-view projection, pictorial drawing, intersections and developments, dimensioning, fasteners, working drawings, technical sketching, shading, patent office drawing, graphs, architectural drawing, structural drawing, topographic drawing, and methods of reproducing drawings.

Included in the appendix, in addition to a number of pertinent and helpful tables, are a description of the decimal system used by the Ford Motor Co., a 6-page bibliography on technical drawing and related subjects, and standard symbols.

Design and Construction of Ducts

"Air Conditioning—Design and Construction of Ducts", by Thomas J. Brett, Engineer-Custodian, Board of Education, Chicago, Ill. Published by American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. 226 pp., 5¾ x 8½ in., clothbound. Price, $2.50.

Aimed to be a practical and easy to understand text on the design, installation, construction and operation of ducts for the distribution of conditioned air, this new book by the author of the "Engineer-Custodian's Manual" treats of the subject in an elementary and somewhat general manner. Among the subjects discussed are duct requirements, calculations, inlet and exit duct openings, air recirculation, installation, materials and construction, insulation, air distribution, and the layout of duct systems for different types of buildings. One chapter is devoted in its entirety to formulas.

Perhaps the most valuable chapter is that on layout of ducts, with illustrative problems worked out in detail.

Schools and Study Courses

A. C. School Issues Report

The Refrigeration and Air Conditioning Institute, 2150 Lawrence Ave., Chicago, Ill., has issued a "report to the refrigeration and air conditioning industry on the occasion of the formal opening of the laboratory and shops" recently. Objectives of the Institute's combined home study and shop training course are outlined by Ray D. Smith, president, the "story behind the training program" is told, photographs of the laboratories and the equipment are included, and the course itself is outlined in detail.

Letters from many of those attending the formal opening give impressions of the course and the Institute's facilities and methods.

Outside Air Conditions for Heating Estimates Recommended by A. C. M. A.

There was published in the July, 1936, HEATING, PIPING AND AIR CONDITIONING (page 98, back section) the application engineering standards for comfort air conditioning recently adopted by the *Air Conditioning Manufacturers' Association* and recommended for the use of *A. C. M. A.* members "pending the formulation of an adequate national standard for air conditioning application under the sponsorship of the proper technical societies."

When the July issue went to press, the complete table (Table 1 of the standards) of outside air conditions to be used for heating estimates was not available, so the first half only of this table was published. The complete table follows:

Table 1—Outside Air Conditions for Heating Estimates

The following table lists the recommended outdoor winter temperature, in degrees Fahrenheit, to use as the basis for preparing heating estimates. These figures should be used unless the customer specifies the temperature upon which the estimate shall be made.

The figures given in this table are not the extreme minimum temperatures recorded in each locality and it is to be expected that lower temperatures will be encountered. However, very low temperatures usually exist only for short periods. It is thus unnecessary and uneconomical to design the heating system for the extreme minimum temperature.

ALABAMA	
Anniston	5
Birmingham	5
Gadsden	0
Mobile	15
Montgomery	10
Tuscaloosa	5
ARIZONA	
Bisbee	15
Flagstaff	—15
Globe	20
Nogales	20
Phoenix	25
Tucson	20
Yuma	20
ARKANSAS	
Fort Smith	10
Hot Springs	5
Little Rock	5
Pine Bluff	10
Texarkana	10
CALIFORNIA	
Bakersfield	15
Fresno	25
Los Angeles	30
Montague	0
Pasadena	25
Sacramento	25
San Diego	35
San Francisco	35
San Jose	20
COLORADO	
Boulder	—15
Colorado Springs	—25
Denver	—20
Fort Collins	—30
Grand Junction	—15
Pueblo	—25
CONNECTICUT	
Bridgeport	—5
Hartford	—5
New Haven	—5
New London	—5
Norwalk	—5
Torrington	—10
Waterbury	—15
DELAWARE	
Dover	5
Milford	5
Wilmington	5
DISTRICT OF COLUMBIA	
Washington	0
FLORIDA	
Fort Myers	35
Gainesville	20
Jacksonville	25
Key West	45
Miami	35
Orlando	35
Pensacola	20
Tallahassee	25
Tampa	35
GEORGIA	
Athens	10
Atlanta	10
Augusta	15
Columbus	10
Macon	15
Rome	10
Savannah	15
Way Cross	20
IDAHO	
Boise	0
Lewiston	5
Pocatello	—5
Twin Falls	—10
ILLINOIS	
Aurora	—10
Bloomington	—10
Chicago	—10
Danville	—5
Decatur	—10
Elgin	—10
Joliet	—10
Peoria	—10
Rockford	—10
Springfield	—10
INDIANA	
Elkhart	—5
Evansville	0
Fort Wayne	—10
Indianapolis	—5
South Bend	—5
Terre Haute	—5
IOWA	
Burlington	—10
Cedar Rapids	—5
Clinton	—10
Council Bluffs	—10
Davenport	—10
Des Moines	—15
Dubuque	—10
Fort Dodge	—20
Keokuk	—10
Marshalltown	—15
Sioux City	—20
Waterloo	—15
KANSAS	
Atchison	—10
Concordia	—10
Dodge City	—10
Leavenworth	—10
Salina	—15
Topeka	—10
Wichita	—5

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To these features add the advantages of the Fretz-Moon "continuous process"—absolute uniformity in every respect; clean, sharp threads; ease of cutting and threading; ease of bending; freedom from hard or "burnt" spots in the metal; freedom from scale; perfectly clean inside and outside; a tight, non-scaling galvanized coating—and the result is a better, longer-lasting pipe that costs less to install and less to use where corrosion is a factor.

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STEEL PIPE

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New Aerofin Crown Orifice *(left)* ● Ordinary Type Orifice *(right)*

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Serious interruptions to plant operations have been traced to scale clogging and consequent freezing of tubes. The new "crown orifice," combined with Aerofin's standard bronze headers, completely eliminates this trouble.

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KENTUCKY	
Bowling Green	0
Frankfort	0
Hopkinsville	0
Lexington	0
Louisville	0
Owensboro	0
LOUISIANA	
Alexandria	20
Baton Rouge	20
New Orleans	25
Shreveport	15
MAINE	
Bar Harbor	—15
Belfast	—5
Eastport	—10
Lewiston	—15
Millinocket	—15
Orono	—20
Portland	—10
Rumford	—20
MASSACHUSETTS	
Amherst	—10
Boston	0
Clinton	—10
Concord	—15
Fall River	—10
Fitchburg	—10
Framingham	—10
Lawrence	—10
Lowell	—15
New Bedford	0
Pittsfield	—10
Plymouth	—5
Springfield	—10
Worcester	—10
MARYLAND	
Annapolis	5
Baltimore	5
Cambridge	5
Frederick	—5
Frostburg	—5
Salisbury	10
MICHIGAN	
Alpena	—10
Ann Arbor	—5
Big Rapids	—15
Calumet	—15
Detroit	0
Flint	—10
Escanaba	—15
Grand Rapids	—10
Kalamazoo	—5
Lansing	—10
Ludington	—10
Marquette	—10
Muskegon	0
Port Huron	—5
Saginaw	—10
Sault Ste. Marie	—20
MINNESOTA	
Alexandria	—25
Duluth	—25
Minneapolis	—20
St. Cloud	—25
St. Paul	—20
MISSISSIPPI	
Biloxi	15
Columbus	15
Hattiesburg	15
Jackson	15
Meridan	10
Natchez	15
Vicksburg	15
MISSOURI	
Columbia	—10
Hannibal	—10
Kansas City	—5
St. Louis	—5
St. Joseph	—10
Springfield	—10
MONTANA	
Anaconda	—15
Billings	—25
Butte	—20
Great Falls	—20
Havre	—30
Helena	—25
Miles City	—35
Missoula	—20
NEBRASKA	
Grand Island	—20
Hastings	—25
Lincoln	—10
Norfolk	—15
North Platte	—20
Omaha	—10
York	—15
NEVADA	
Las Vegas	20
Reno	—5
Tonopah	5
Winnemucca	—15
NEW HAMPSHIRE	
Berlin	—25
Claremont	5
Concord	—20
Franklin	—15
Hanover	—20
Keene	—20
Nashua	—15
NEW JERSEY	
Asbury Park	5
Atlantic City	10
Bayonne	5
Belvidere	—10
Bridgeton	5
Dover	0
Elizabeth	0
Englewood	—5
Jersey City	5
Lambertville	—5
Long Branch	5
Newark	5
New Brunswick	0
Paterson	—5
Phillipsburg	—5
Plainfield	—5
Somerville	—5
South Orange	—5
Trenton	5
NEW MEXICO	
Albuquerque	5
Raton	—5
Roswell	—10
Santa Fe	0
NEW YORK	
Albany	—5
Auburn	—5
Binghamton	—10
Buffalo	—5
Cortland	—10
Elmira	0
Glens Falls	—15
Ithaca	—15
Jamestown	—10
Lake Placid	—20
Little Falls	—20
Lockport	—5
New York City	0
Norwich	—15
Ogdensburg	—20
Oneonta	—15
Oswego	—10
Port Jervis	—5
Rochester	—5
Syracuse	—15
Watertown	—15
NORTH CAROLINA	
Asheville	5
Charlotte	10
Greensboro	15
Newbern	20
Raleigh	15
Salisbury	10
Wilmington	20
Winston Salem	10
NORTH DAKOTA	
Bismarck	—30
Devils Lake	—30
Grand Forks	—25
Jamestown	—25
Minot	—30
Williston	—35

OHIO	
Akron	—5
Cincinnati	—5
Cleveland	—5
Columbus	—10
Dayton	—10
Ironton	0
Lancaster	—5
Lima	—5
Marion	—10
Sandusky	0
Toledo	—5
Warren	—10
OKLAHOMA	
Ardmore	10
Bartlesville	—10
Guthrie	—5
Muskogee	0
Oklahoma City	—5
Tulsa	—5
OREGON	
Baker	0
Eugene	15
Pendleton	—15
Portland	15
Salem	15
Wamic	0
PENNSYLVANIA	
Altoona	—5
Bethlehem	—5
Clearfield	—10
Coatesville	—5
Erie	0
Franklin	—15
Harrisburg	5
Lancaster	—5
Lebanon	—5
New Castle	0
Philadelphia	5
Pittsburgh	—5
Reading	—5
Scranton	—10
Warren	—15
Williamsport	—5
York	—5
RHODE ISLAND	
Bristol	0
Providence	0
SOUTH CAROLINA	
Charleston	20
Columbia	15
Florence	20
Greenville	15
Spartanburg	15
SOUTH DAKOTA	
Aberdeen	—30
Huron	—20
Rapid City	—20
Sioux Falls	—20
Watertown	—20
TENNESSEE	
Chattanooga	15
Jackson	10
Johnson City	0
Knoxville	10
Memphis	5
Nashville	5
TEXAS	
Abilene	15
Amarillo	—5
Austin	10
Brownsville	30
Corpus Christi	20
Dallas	10
Del Rio	15
El Paso	10
Fort Worth	10
Galveston	25
Houston	25
Palestine	15
Port Arthur	10
San Antonio	20
Waco	20
UTAH	
Logan	—15
Ogden	—10
Salt Lake City	—5
VERMONT	
Bennington	—10
Burlington	—10
Newport	—15
Rutland	—20
VIRGINIA	
Charlottesville	10
Danville	10
Lynchburg	10
Norfolk	15
Petersburg	10
Richmond	10
Roanoke	5
WASHINGTON	
Aberdeen	10
Bellingham	10
Everett	10
Olympia	10
Seattle	10
Spokane	—10
Tacoma	10
Walla Walla	—10
WEST VIRGINIA	
Bluefield	—10
Charleston	0
Elkins	—10
Fairmont	—10
Huntington	—5
Martinsburg	—5
Parkersburg	—10
Wheeling	—5
WISCONSIN	
Ashland	—20
Beloit	—10
Eau Claire	—20
Green Bay	—20
La Crosse	—25
Madison	—10
Milwaukee	—10
Oshkosh	—15
Sheboygan	—10
WYOMING	
Casper	—20
Cheyenne	—20
Sheridan	—30

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 110. Add the new products and companies listed here to your Directory Section which you received in your January 1936 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

Electronic Tube Heating System Control

No. 1031—New "Radiostat" electronic tube control for commercial building heating systems up to 300 hp capacity com-

The Oldest

—yet the most MODERN Underground Steam CONDUIT

Ric-wiL Underground Conduit Systems for steam pipes were first put on the market in 1910, and were the pioneer systems. Even 26 years ago, when comparatively little was known of the modern scientific technique of sub-soil steam conveyance, Ric-wiL was a meritorious product. Since that date numerous basic advances in design, as well as refinements of detail, have consistently kept Ric-wiL not only abreast but ahead of competition. It is recognized today as THE Standard for measuring underground steam conduit efficiency.

Correctly engineered and drained, Ric-wiL keeps steam lines tight, dry and over 90% efficient. A wide variety of designs and materials to meet all possible conditions. Obtainable with various insulation, including the famous Ric-wiL Watertight Asbestos Dry-paC. Ric-wiL service is complete from coast to coast—installation, engineering, field supervision. Write for complete catalog.

UNDERDRAINAGE IS VITAL

Heat loss from conduit in wet soil is over four times that in dry soil. Ric-wiL External Underdrain keeps the soil *dry*.

The Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio

New York San Francisco Chicago

Agents in principal cities

REGISTERED IN U. S. PATENT OFFICE

RIC-WIL

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

Pat. No. 2,023,749

Here Is WHY Air Conditioning Engineers Are Using FEDDERS COILS and VALVES

1. Factory engineered manifolding provides correct distribution of refrigerant throughout each section of the coil, and eliminates hazards of field assembly.
2. Multiple use of Fedders Model 33 High Capacity Thermostatic Expansion Valves doubly assures proper distribution of refrigerant. Their easy, sensitive adjustment aids accurate refrigerant control.
3. All coils and manifolds tested with high pressure. Approved by Underwriters' Laboratories.
4. Copper Fins and Copper Tubes properly proportioned, assure maximum heat transfer efficiency.
5. Cleaned and absolutely dehydrated to provide a clean, dry interior.
6. Cataloged in complete lines of standard models to simplify engineering and installation. Built for use with refrigerant, cold water, hot water or steam.

FEDDERS MANUFACTURING COMPANY
57 Tonawanda St. Buffalo, N. Y.

Atlanta Boston Chicago Cincinnati Dallas Los Angeles New York Philadelphia

prises a sensitive device installed outside of the building maintaining inside temperature within 1 F by governing stoker operation to constantly vary the pressure or vacuum carried on the boiler. There are no moving parts other than the motor starting relay, and operation does not depend upon a timing device or contact making thermostat.

The manufacturer claims that a saving of 15 per cent or more in the use of steam above the boiler room is possible, as accurate stoker control is maintained not only during the 5 per cent of the time when maximum heat requirements are in effect, but during the other 95 per cent of the time as well. Once installed and adjusted, no further attention need be given the control regardless of weather conditions, and the heat elements and master control are therefore locked after installation.—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

Pillow Block Has Rubber Housing

No. 1032—New ball bearing pillow block for uses where noiselessness and economy must be combined in an anti-friction unit supporting light loads, has one piece housing entirely of molded rubber. The rubber block supports a standard steel radial ball bearing of double-shielded type, which is pressed into the housing, followed by a shielding plate, a rubber insulating washer, and a thrust collar which clamps the bearing in place. Bearing is pre-lubricated. Exterior of housing is treated with a protective lacquer to prevent deterioration.

These pillow blocks are available for shaft sizes from $\frac{1}{8}$ to $1\frac{7}{16}$ in.—The Fafnir Bearing Co., Booth St., New Britain, Conn.

Corkboard Insulation for Ducts

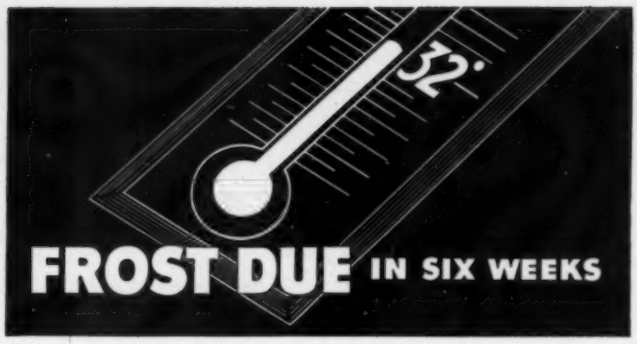
No. 1033—A new type of corkboard insulation ½ in. thick for ducts has been developed to meet the requirements of small commercial air conditioning installations, where the main problem is to prevent condensation rather than to conserve refrigeration; where insulation is required to conserve refrigeration, standard corkboard in heavier thickness should be used.

This new "DI" corkboard is not affected by moisture, states the manufacturer, and a thin mastic coating on one side strengthens the material, increases its flexibility, seals it against moisture penetration, and provides a finish. Can be erected readily in waterproof cement or asphalt and, because of its light weight, reinforcement with wires or bands is not necessary in many cases. Thermal conductivity value is said to be exceptionally high due to its special light density. Available only in ½ in. thickness in 12 x 36 in. sheets.—Armstrong Cork Products Co., 994 Concord St., Lancaster, Pa.

Redesigns Small Building Air Conditioner

No. 1034—The "Climate Changer" has been redesigned to present a more efficient and compact year 'round air conditioner for small buildings and residences, states the maker. New features include target type humidifier; ½ in. layer of insulation lining

the bottom of the unit where cold condensation water is drained from the dehumidifying coils to prevent sweating and the possibility of damage to any goods stored beneath the unit; arrangements for easy access to the interior of the unit.



AUTOMATIC EQUIPMENT FOR EVERY TYPE OF HEATING SYSTEM...

All Products of General Motors

Delco-Heat offers a complete line... and each product is backed by a famous name

IN a few short weeks the fall rush will be on in the heating business. This year that period will see more oil burners, and other automatic heating equipment installed than ever before in a similar period.

A substantial share of this business in every neighborhood will be done by dealers who sell Delco-Heat. The Delco-Heat line includes everything from moderate size conversion burners to complete automatic heating and air conditioning plants.

The public acceptance of Delco-Heat has brought it to a position among the leaders in the field, in a matter of scarcely five years. Quality of construction, economy of operation and confidence in the reputation of General Motors, have been responsible for this success.

DELCO-FRIGIDAIRE CONDITIONING CORPORATION

AUTOMATIC HEATING **DAYTON, OHIO** *AIR CONDITIONING*

PRODUCTS OF GENERAL MOTORS

MAIL COUPON TO ABOVE ADDRESS—Dept. HPAC 8

I want to know more about Delco-Heat Conditionair. Send illustrated literature.

Name_____

Street_____

City and State_____

FRIEZ BALTIMORE

THE HUMIDITY CONTROLLER

Satisfied customers have made the Friez Humidistat the nonpareil in all humidity control . . . either for comfort or industry. The pioneer human hair elemented instrument, its four years of life sees it now as the type in outstanding demand. Standard fitment with most leading builders of air-conditioning equipment, it will serve you well. You can be sure of hair-trigger control for either high or low points of humidity.

YOU WILL HAVE NO FURTHER HUMIDITY CONTROL PROBLEMS, IF YOU INSTALL A FRIEZ HUMIDISTAT.

Now for insertion in return-air ducts, and for numerous industrial purposes the same reliable functioning is assured in a mounting exactly adapted for these special needs.

Write for Bulletin

JULIEN P. FRIEZ & SONS, Inc.

"The Makers of America's Weather Instruments"

BALTIMORE MARYLAND

FRIEZ BALTIMORE

CORINCO CORK BOARD

STANDS THE TEST

10,000 lbs. of Cut and Wrapped Meat Were Removed Without Loss

Dramatic evidence why Corinco Cork Board permits minimum insurance premiums

This Corinco Cork insulated refrigerator box not only withstood the ravages of a wind-fanned blaze, but Corinco Cork Board was responsible for maintaining a temperature less than 21° F during the day the fire was in progress.

No laboratory test ever devised proved as conclusively the fire retarding properties of Corinco Cork Board as the snapshot pictured here.

CORK INSULATION COMPANY INC.
155 EAST 44TH STREET NEW YORK CITY, N. Y.
BRANCHES AND DISTRIBUTORS IN PRINCIPAL CITIES · FACTORY: WILMINGTON, DEL.
MANUFACTURERS OF CORINCO SHEET CORK · CORINCO GRANULATED CORK · CORINCO CORK PIPE COVERING

A lighter but sturdy base makes unit less cumbersome and facilitates installation. In accomplishing this the motor was moved from where it had previously been attached to an extension of the heavy base to an individual mounting on the side of the unit where it is easily serviced.

Six convenient methods of suspension have been designed to allow the installer a wide range from which to fill the particular requirements of each job.—The Trane Co., 303 S. 11th St., La Crosse, Wis.

Valves for Copper Piping

No. 1035—Complete line of "Solder-End" valves for 150 lb service on copper lines introduced. Available at the same price are both the plain sweated and Mueller "Streamline" type ends, the latter being manufactured under license of Mueller Brass Co. With the exception of the ends, these new valves are identical with the manufacturer's standard valves used for threaded installations.—Jenkins Bros., 80 White St., New York, N. Y.

New Design of Sound Level Meter

No. 1036—A sound level meter which will give a quantitative measure of noise independent of the personal element, and at the same time give results commensurate with the sensations experienced by the ear, has been developed to provide performance in accord with the newly adopted *American Standards Association* standards. Special precautions have been taken to make the amplifier unit of the instrument suitable for use in the neighborhood of electrical machinery where stray magnetic fields are common. The complete instrument, including microphone, tripod, calibrating unit, and batteries is contained in a compact metal case 15¾ x 9½ x 8¼ in., carrying weight approximately 39 lb. Range is 30 to 120 decibels.—General Electric Co., 1 Rice Rd., Schenectady, N. Y.

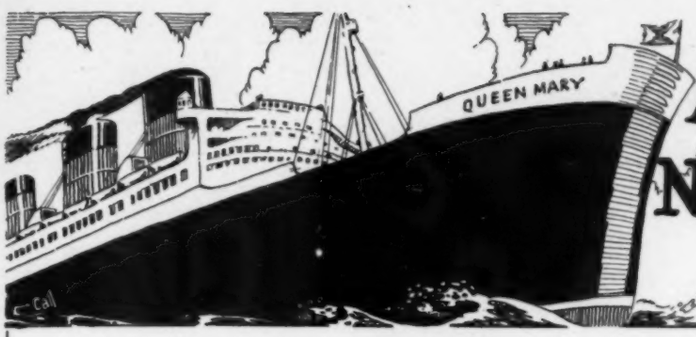
Flexibility Features Refrigerant Charging Connection

No. 1037—Feature of flexible charging connection for the use of service, installation, and operating engineers who have occasion to charge "Freon" refrigerating or air conditioning systems is its easy flexibility, an advantage in making temporary connections from a refrigerant cylinder to the refrigerating system.

The connection is 4 ft long, and is made of seamless bronze bellows tubing with a reinforcing armor of heavy bronze wire braid. It is provided with ⅜ in. *S. A. E.* flared nut connections at each end, with an adaptor fitting for connection to standard size refrigerant cylinders.—York Ice Machinery Corp., Roosevelt Ave., York, Pa.

Lubricating Oils for A. C. Field

No. 1038—Need of the air conditioning and refrigeration industries for lubricating oils having quality characteristics especially suited to the distinctive type of service under which they must function, has been recognized in the announcement of the com-



Actual Delivery-Not Distance Counts

Speed!

The speed of modern transportation plus our exact and rapid production of fin tube surface, eliminate distance as a factor.

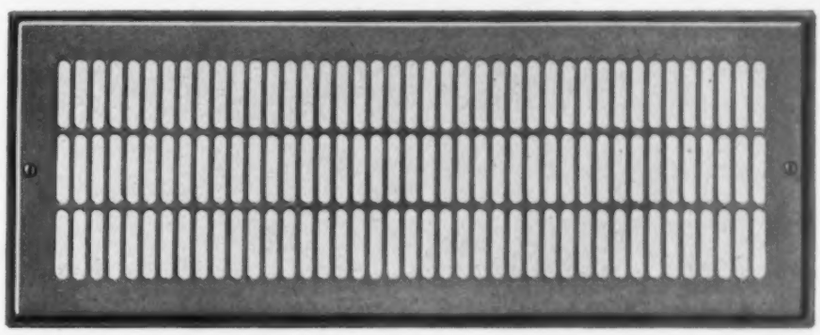
Thirty-two combinations of fin and tube sizes and fin spacing can be fabricated into coils any number of tubes high or wide and in lengths to twelve feet.

THE BUSH MFG. CO., HARTFORD, CONN.

BRANCH FACTORY, 610 NO. OAKLEY BLVD., CHICAGO

BRANCH OFFICES: NEW YORK, DETROIT, CHICAGO, DAYTON, CLEVELAND, PHILADELPHIA AND LOS ANGELES

AUER
Air Conditioning Registers
Add to the Results of Any System



Satisfaction in air conditioning equipment is highly dependent on correct details of register design. In Auer directional air-flow registers, the blades (furnished for airstream in any direction) are ample in size and positive in position. Unusual structural strength in combination with maximum free circulation area. Auer Quality Registers and Grilles are expertly designed and built — to enhance the effectiveness of ANY air conditioning system.

● The famous AUER CLASSIC face (shown above) is a design of character and restraint, in good taste in the finest of modern interiors. Write for Air Conditioning Register Catalog 36A ●

THE AUER REGISTER COMPANY, 3608 PAYNE AVENUE, CLEVELAND, OHIO

AUER DISTINCTIVE REGISTERS & GRILLES For Air Conditioning *and* Gravity

pletion of a new series of such oils under the brand name "Capella," the result of a two year research program. The series, solvent processed and dehydrated, is composed of six numbers or grades, ranging from AA, having a viscosity of 70 seconds SUV to E, having a viscosity of 500 seconds SUV at 100 F. It is stated that these oils have established outstanding performance records in the laboratory and in plant service on all types of refrigeration units, both in the electric refrigeration and air conditioning field and in stationary plant units.—The Texas Co., 135 E. 42nd St., New York, N. Y.

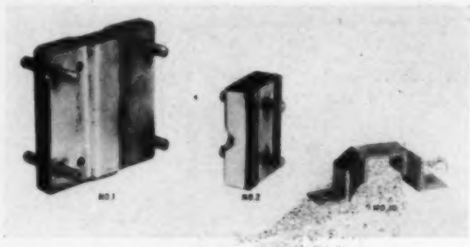
Unit Conditioner Has Three Refrigeration Machines

No. 1039—Unit air conditioner which will cool, dehumidify, ventilate and filter the air in an average sized room, instead of utilizing one large refrigeration machine, is equipped with three, smaller, hermetically sealed units which are stated to be extremely quiet in operation. These units are started automatically one after the other so as to avoid an overload on the ordinary lighting circuit, making it possible to plug the machine in any light socket without special wiring.

The only installation work which is necessary is the placing of a telescopic duct connection in a partly opened window. This duct introduces outside air for ventilation, as well as a supply of air for cooling the air-cooled condensers.—General Electric Co., Bloomfield, N. J.

New Line of Vibration Isolators

No. 1040—New standard line of vibration dampening rubber-to-metal mountings, known as "Vibro-Insulators," are designed for bases of machines, electric and combustion motors, generators,



vibrating screens and reciprocating mechanisms. Of the shear type, these mountings consist of an age-resisting rubber bonded to two metal plates, one of which is fastened to the vibrating member and the other to the support or foundation. The rubber is attached to the metal plates with a brass plating type of bond which gives an adhesion of 200 lb per sq in.

They are stocked in three types. Type No. 1 has a maximum load capacity of 800 lb and a minimum frequency of 800 vibrations per minute. Type No. 2 will support a maximum load of 200 lb and has a minimum frequency of 1200 vibrations per minute. Type No. 10, which is of the double shear type, has a minimum frequency of 1000 vibrations per minute and is available in a range of sizes for loads of 50 to 3000 lb.—The B. F. Goodrich Co., Mechanical Rubber Goods Div., Akron, Ohio.

Young Unit Heaters, both the suspension and floor models, provide a most satisfactory and economical method of heating all types of industrial buildings.

Young Blast Units and Commercial Heat Transfer Surfaces are compact efficient units designed to operate in connection with central fan systems where their function may be for heating or cooling. They are also used in air conditioning equipment or for commercial applications for drying, processing, etc. Send for catalogs 534, 435, and 336.

Offices in all principal cities.

YOUNG RADIATOR COMPANY, RACINE, WIS.

Young Quality

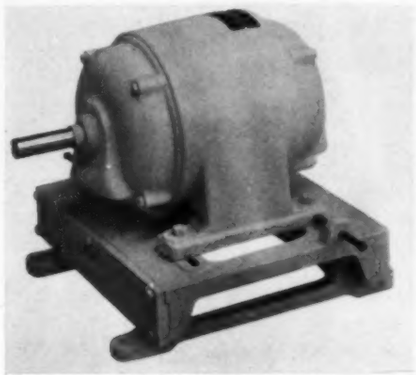
Fluid Joint Breaker

No. 1041—"Pen-a-trate" joint breaker is a fluid which filters quickly into the threads of corroded joints. Upon coming in contact with the corrosion, it forms a gas which dissolves the rust into a fine powder, the maker states.

It is for use on joints, bolts, studs, etc., where corrosion has made removal impossible without breaking.—Grapho Products, Inc., 2232 Alvord St., Indianapolis, Ind.

Sound-Proof Bases for Fans and Motors

No. 1042**—New "Sound-Pruf" base for motors, fans, blowers and other equipment, consists of a floating platform suspended by resilient rubber balls set into recesses between parallel flanges; the number of balls can be adjusted to suit the weight and conditions under which they operate. The bases are suitable

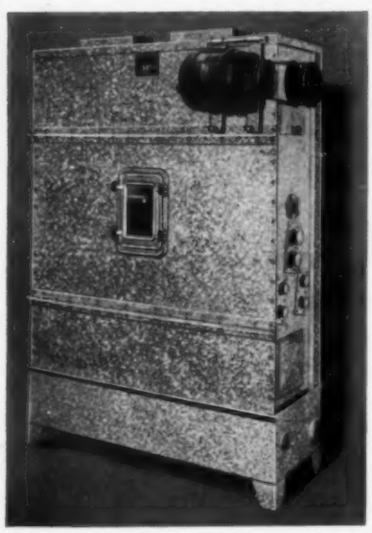


for belt drives, as motor alignment is maintained for any reasonable belt tension. The motor support platform is slotted and has adjusting screws for belt adjustment.

Bases are designed to fit *N. E. M. A.* standardized motor dimensions. Universal bases for fractional hp motors also available, made with slotted feet for belt adjustment instead of having adjusting screws.—W. D. Fabling Co., 2043 Sacramento St., Los Angeles, Cal.

Evaporative Condensers for Air Conditioning

No. 1043—New type "ECC" evaporative condensers available in capacities from 4½ to 52 tons, are suitable for "Freon" or methyl chloride and can be arranged for indoor or outdoor installation. According to the manufacturer, these condensers will save over 90 per cent of the water used for direct cooling of condensers and the make-up water required will not exceed 0.03 gpm per ton of refrigeration.



Tank is welded steel, and casing and eliminators are galvanized copper bearing steel. Fans are multi-blade type with ball bearings. The copper tube and fin coils are arranged for bleeding liquid as condensed to increase effectiveness and reduce pressure loss. The bronze nozzles, of two piece construction, have large passages to prevent clogging, and a removable suction screen is provided in the tank. The pump is of

Wolverine Tubing
Insures You Against Profit Eating Service Calls

Use Wolverine Tubing in your automatic heat or air conditioning installations—it will insure you against profit eating service calls arising from the tubing.

Made from corrosion defying 99.9% pure copper, Wolverine Tubing is fabricated by our special extrusion process which assures a clean bright tube with a mirror-like inside finish. There can be no scale, shop dirt, or sediment to clog fuel oil or water lines, or valves.

Temper is uniformly soft and even—bending, cutting, flaring and other installation work is exceptionally easy.

Size is accurate—wall thickness is uniform—assuring tight joints with either flared or soldered fittings.

Wolverine Tubing is always available at local supply houses—in either straight lengths for rigid piping or in soft temper coils for threading through walls.

Standardize on Wolverine.

Wolverine Copper Water Tubing (⅜" to 2") for underground gas, gasoline and oil connections has been tested and listed under Re-examination Service of Underwriters' Laboratories.

WOLVERINE TUBE CO.

SEAMLESS COPPER BRASS & ALUMINUM

1411 Central Ave., Detroit, Mich.

the close coupled type, single suction, bronze fitted, connected directly with the motors to eliminate pump bearings.

A removable section of the casing allows complete access to the interior of the unit, and if necessary, coils and eliminators can be removed through this opening. The unit is also provided with a cast iron watertight inspection door supplied with a glass panel—Buffalo Forge Co., 490 Broadway, Buffalo, N. Y.

Registers and Grilles for Forced Air

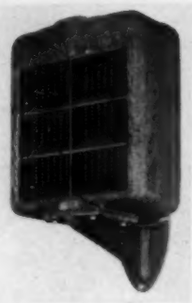
No. 1044—New nozzle type "Air-Master" registers and grilles act upon the air flow through an orifice similar to the manner in which spray nozzles control the flow of liquids, according to the maker. Paths of air may be converged to provide the type of distribution required, whether it is a sudden or rapid diffusion or long distance ejection.

Many varied jet openings are available. Rigid exterior bars, placed horizontally, provide vertical control and also form a solid protective grille front for the interior adjustable bars, which are placed vertically and provide lateral control. The manufacturer states that free areas, allowing for border deductions, are not under 70 per cent in the smallest size, and in many cases are more than 80 per cent.

Six styles of grille formation are supplied with any of the jet openings, the difference in each style occurring only in the type and arrangement of the interior bars, their spacings and design—The Waterloo Register Co., Waterloo, Ia.

All Electric Unit Heater

No. 1045*—New all electric unit heater has dual heating control providing high heat for quickly heating up, and low heat for maintaining the temperature. Unit comprises an all copper core with cast top and bottom tanks, with electric immersion heating



elements enclosed in the bottom tank for heating a non-freezing liquid. Heat is distributed to the air through the 5,112 sq in. of copper heat transfer surface of the core.

Power consumption is 6,000 watts for high heat, 3,500 watts for low heat. Maximum Btu output is 20,500 and the minimum Btu output 11,950. Air circulation is 250 cfm and the motor is standard, 220 volts, 60 cycle a-c, but special motors can be furnished. A safety switch is provided which will shut off the electric current, if necessary—Hexcel Radiator Co., 18th St. & Fleet Ave., Racine, Wis.

Comfort Cooling Units Use Ice

No. 1046**—New "Kool-Kleen" ice-using cooling units made in two sizes, one with 150 lb ice capacity, 14 in. wide by 30 in. high by 37 in. long, and the other with 300 lb ice capacity, 14 in. wide by 30 in. high by 59 in. long. Manufacturer states that the first has an average effective cooling area of 100 to 200 sq ft of floor space, and the second 200 to 300 sq ft.

Unit comprises an ice chamber, cooling and dehumidifying chamber, scrubbing plates, fan and pump. According to the manufacturer, the air is cooled in three stages—pre-cooling by evaporation of water, cooling by contact with cold water spray, and super-cooling by direct contact with the ice cake.

Mounted on rubber tired wheels, the unit is portable—Kool-Kleen Conditioning Co., E. Seventh & Division Sts., Sioux City, Ia.

THERM-O-TILE

STEAM CONDUIT

6000 feet of THERM-O-TILE, for steam distribution, was used at the Federal Housing Project, Techwood, Atlanta, Ga. Covers 25 acres. Supplies steam to

700 FAMILIES

Ask for Bulletin 351 describing complete details of the THERM-O-TILE Conduit System.

Now being installed at Cedar Central Housing Project, Cleveland, Ohio.

Approved in specifications for use in other Federal Housing Projects.

Sold and installed by Johns-Manville Construction Units in All Principal Cities. *Inquiries referred to them or to us will bring you complete information.*

H. W. PORTER & CO., INC.

825 Frelinghuysen Ave., Newark, N. J.

Comfort Cooled Desk

No. 1047**—Employing the same principle as utilized for the "air conditioned bed" announced some months ago, the same manufacturer has introduced the "air conditioned office enclosure" illustrated here. The enclosure measures 6 ft. 2 in. by 6 ft. 2 in. by 4 ft 8 in. high; a larger enclosure, 9 ft by 9 ft by 6½ ft, is

also made. The spot cooling principle involved is that cold air, being heavier than warm air, falls by gravity into the enclosure, diffusing as it falls, and hence, no drafts are evident. According to the manufacturer, a reduction of from 15 to 20 F is obtained in the enclosure.

The cooling unit comprises a ⅓ hp motor, a 2 cylinder "Freon" compressor and an air cooled condenser. On the lower side of the evaporator coil case is a 3½ gal tank into which the condensate drains. The unit for the larger office enclosure has a ¾ hp motor—Clark Equipment Co., Buchanan, Mich.

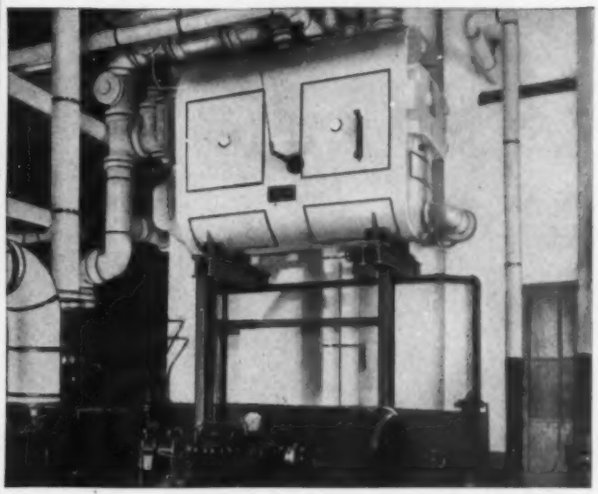
Cold Water Type Unit Coolers

No. 1048—New cold water type unit cooler recently placed on the market provides 360 degree rotability and can be turned in any direction without changing existing piping connections by merely loosening a lock-nut and two unions. Vertical fins and a specially insulated drain tank make it unnecessary to use a moisture eliminator, states the manufacturer, and thus no mechanical change is necessary to convert the cooling unit into a heating unit.

Unit consists of a copper condenser or cooling coil enclosed in an insulated steel casing to which is attached the motor fan and assembly. The condenser is made up of a series of horizontal seamless copper tubes having vertical copper fins metallically bonded to them. This casing is insulated with ¼ in. sheets of cork and the steel bottom pan is lined with ¾ in. of rockwool insulation. Exterior of unit is satin finish, black baked enamel with trimmed strips of polished stainless steel. Made in four sizes, two for use where quiet is essential, and the other two for larger areas and for process applications. The latter two may be used where quietness is a factor, if proyided with two or three speed motors—Modine Mfg. Co., 17th St., Racine, Wis.

Are you sure that your boiler feedwater heaters are full-efficiency units?

WORTHINGTON DEAERATING FEEDWATER HEATERS



WILL HEAT FEEDWATER TO THE SAME TEMPERATURE AS THE HEATING STEAM ...THIS IS FULL FUEL-SAVING EFFICIENCY

Also...by removing free oxygen from the feedwater . . . they

- INCREASE BOILER EFFICIENCY
- REDUCE BOILER REPAIRS
- REDUCE BOILER CLEANING
- PROLONG LIFE OF BOTH BOILER AND PIPING

WORTHINGTON Feedwater Heaters are built to meet individual plant requirements . . . and experienced Worthington engineers are available to assist you with your feedwater problems.

● *Literature on request*

WORTHINGTON PUMP AND MACHINERY CORPORATION
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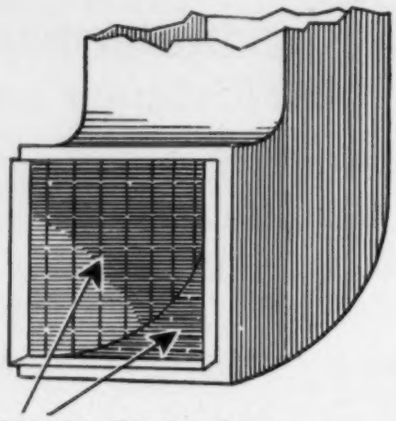
A-92265 *Offices and Representatives throughout the World*

WORTHINGTON



Ozite Hair Felt Duct Lining

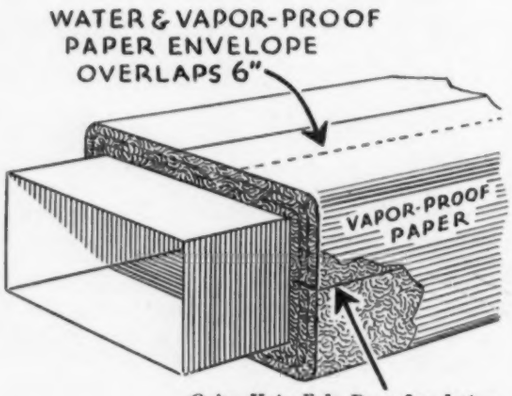
Modernization

Is More Profitable When You Use Ozite

Now, when you are bringing heating plants and air conditioning systems up-to-date, you can give better values to customers and still make bigger profits on each job if you use Ozite Hair Felt for the insulation and sound deadening of air ducts.

Ozite Duct Insulation and Ozite Duct Lining are furnished in forms which greatly simplify installation. The Duct Insulation is in rolls and can be wrapped around the ducts and cut to fit in record time. The Duct Lining is furnished in rolls, felted with burlap backing and latex facing, and is equally easy to apply to interiors of air ducts, regardless of their shape. Write for illustrated folder, giving complete specifications!

AMERICAN HAIR & FELT CO.
MERCHANDISE MART CHICAGO, ILL.



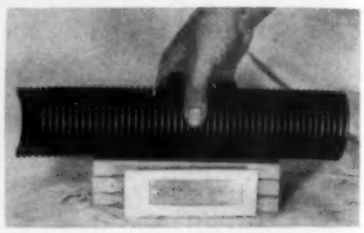
Ozite Hair Felt Duct Insulation

Ozite HAIR FELT AIR DUCT LINING and DUCT INSULATION
FOR ALL SOUND, HEAT AND COLD INSULATION PURPOSES

Seamless Flexible Metal Hose

No. 1049**—Seamless flexible metal hose has been designed for use as a means of conveying non-solids and non-abrasives where conditions of flexing and expansion are encountered between delivering and receiving connections. The design and construction is particularly suited to high pressures and temperatures, the manufacturer states.

The hose is manufactured from a seamless tube which is corrugated into a bellows-like form with the adjacent corrugations parallel to each other and rounded at the top and bottom. Advantages are stated to be greater flexibility due to the true bellows form of the corrugations, greater durability through elimination of torsional strains on the hose under pressure conditions, reduced bending radii because of the extreme depth and form of the corrugations. Also, the parallel corrugated tubing permits simplifying the design of certain fittings. The drawing process employed in the manufacture makes possible the furnishing of hose in many alloys, including monel metal. Available in various types of braid and alloy construction.

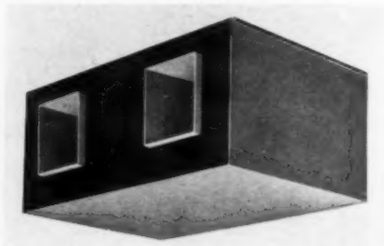


In monel metal the tubing is produced in sizes from ⅛ in. to 2 in. in inside diameters, and in steel it has been produced in inside diameters to 40 in.—Eclipse Aviation Corp., 545 N. Arlington Ave., East Orange, N. J.

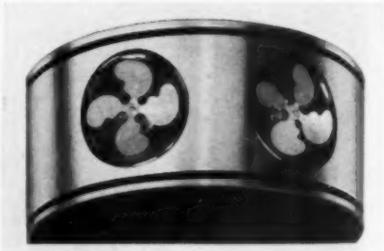
Floor and Ceiling Type Air Conditioning Units

No. 1050—New line of air conditioning units includes floor type, ceiling type and "Band Box" ceiling suspension models.

Features of floor and ceiling types include galvannealed casings with galvanized framing, coils with equalized feed to insure proper distribution of refrigerant, and pressure blowers. The units are not equipped with filters, but may be used with any standard filter of adequate capacity. Both the floor and ceiling types are available in twelve capacity ratings from 1 to 20 tons, handling from 710 to 12,000 cfm.



The "Band Box" comfort cooler is of ornamental design with aluminum case and black trim for applications where the standard unit cooler would be out of place. The coils are furnished for three point suspension by means of hanger bolts secured to the ceiling joists or by through bolts with heads flush with floor above. Each unit has two fans, and air is drawn through fin coils and discharged from openings in the face of the unit. The refrigerant coils are equipped with internal fins to secure maximum heat transfer and moisture condensation.



Four sizes are available for ratings of 9,000, 12,000, 18,000 and 24,000 Btu per hr—Peerless Ice Machine Co., 515 W. 35th St., Chicago, Ill.

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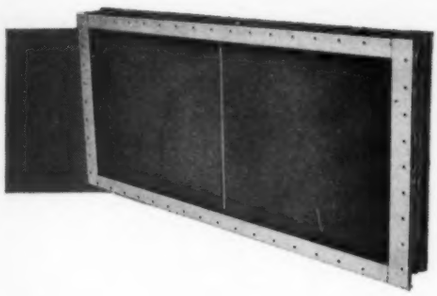

There are thousands of TRANE Blast Coil installations serving in all types of heating, drying and processing applications. Whether high or low pressure steam is to be used, there is a proper TRANE coil for the job. They are compact and lightweight, and the result is often a tremendous saving in valuable space.

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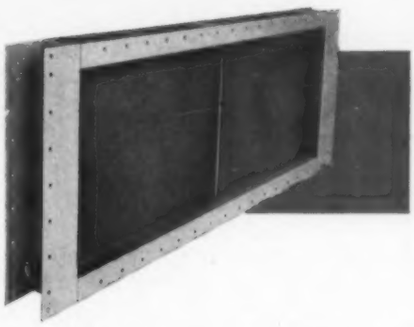
The TRANE Company also manufactures a complete line of cooling coils, process coolers, evaporative condensers, and other industrial and commercial air conditioning equipment.



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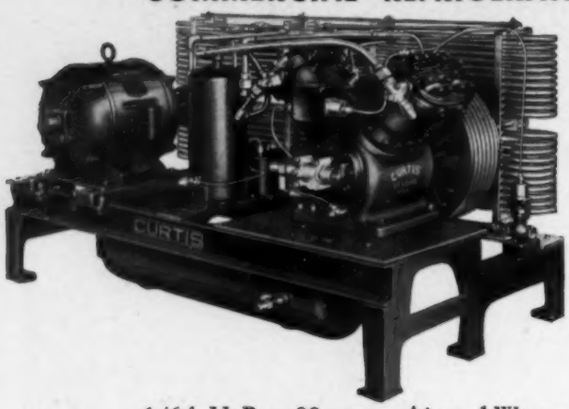

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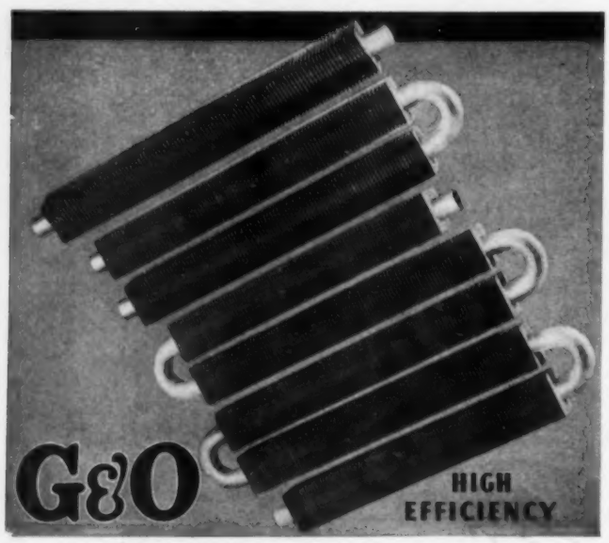

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Conventions and Expositions

National Association of Power Engineers: Annual convention and exhibit, August 31-September 4, Stevens Hotel, Chicago, Ill. Secretary, F. W. Raven, 176 W. Adams St., Chicago, Ill.

World Power Conference: September 7-12, Washington, D. C. American National Committee, Interior Bldg., Washington, D. C.

American Welding Society: Annual meeting, October 19-23, Hotel Cleveland, Cleveland, Ohio. Headquarters Office, 33 W. 39th St., New York, N. Y.

American Gas Association: Convention, week of October 26th, Atlantic City, N. J. Headquarters Office, 420 Lexington Ave., New York, N. Y.

National Association of Practical Refrigerating Engineers: Annual meeting and exhibit, November 10-13, Drake Hotel, Chicago, Ill. Secretary, Emerson Brandt, 228 N. LaSalle St., Chicago, Ill.

Twelfth National Exposition of Power and Mechanical Engineering: November 30-December 5, Grand Central Palace, New York, N. Y. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Mechanical Engineers: Annual meeting, November 30-December 5, New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

National Warm Air Heating and Air Conditioning Association: Winter meeting, December 15-17, Stevens Hotel, Chicago, Ill. Managing Director, Allen W. Williams, 50 W. Broad St., Columbus, Ohio.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 110

No. 2066—AIR CONDITIONERS: Kewanee Boiler Corp., Kewanee, Ill. 4 p. bulletin describing "Type RK" winter air conditioner units for smaller buildings for heating, humidifying, filtering and year 'round air circulation; in three sizes, 400, 500 and 700 E.D.R.; 1100, 1400 and 2000 cfm. Features include viscous throw-away filter, heating coil of copper tubes with aluminum fins and cast iron headers, self cleaning humidifying nozzles, control cabinet and acoustically lined blower fan.

No. 2067—AIR CONDITIONING: Carbondale Machine Corp., Worthington Ave., Harrison, N. J. 20 p. booklet illustrating many of this company's air conditioning installations in various types of buildings, including the New York Stock Exchange job installed in 1905.

No. 2068—AIR CONDITIONING: Frick Co., Waynesboro, Pa. (a) 16 p. booklet devoted to representative refrigeration and air conditioning installations in theaters, hotels, restaurants, hospitals, stores and industrial plants, listing name, location, number and size of refrigerating machines, and refrigerant, for some 275 jobs. (b) Vol. 7, No. 12 of "The Frick System," describing air conditioning of fourteen stories of a New York office building with two "Freon" machines. Details of the Department of Agriculture air conditioning system are also given.

No. 2069—AIR CONDITIONING: Servel, Inc., Evansville, Ind. 16 p. booklet presenting pictorially and with brief text the advantages of air conditioning, and describing this company's equipment.

No. 2070—AIR CONDITIONING PIPE AND FITTINGS: The Henry Furnace & Foundry Co., 3480 E. 49th St., Cleveland, O. Catalog covering "Moncrief" air conditioning pipe and fittings, illustrating methods of installing prefabricated duct systems, giving instructions for ordering fittings, and showing tables of dimensions and list prices of fittings.

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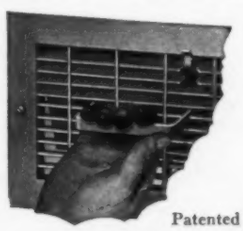

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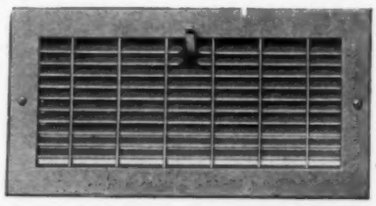

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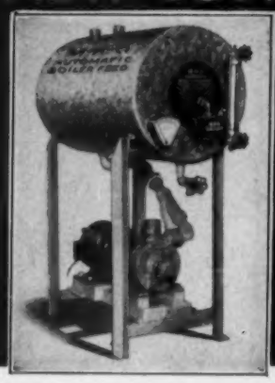

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No. 2071—AMMONIA VALVES AND FITTINGS: Frick Co., Waynesboro, Pa. 36 p. catalog of ammonia valves and fittings, arranged for quick reference, each piece being priced both separately and complete with companion flanges, bolts and gaskets. Dimensions and weights of the pieces are shown. Among the new items included are electric control valves, oil type liquid level indicators, diffusers, bolts and nuts, gaskets, pipe hanger fittings and repair parts for ammonia valves. Six pages are devoted to tables of useful technical data.

No. 2072—BLOWERS: Roots-Connersville Blower Corp., 16th St. & Columbia Ave., Connersville, Ind. 4 p. folder on the application of blowers to raw water ice plant service, describing in detail this company's centrifugal and rotary blowers.

No. 2073—CIRCULATORS: Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill. 4 p. folder on "Hydrolators," water circulators for hot water heating systems and domestic service water, presenting advantages, features of construction, typical installation sketches and specifications.

No. 2074—COAL BURNING: Cokal Pulverzone Corp., 155 E. Superior St., Chicago, Ill. 4 p. bulletin on automatic coal burning equipment combining stoker firing, pulverized coal burning and automatic combustion control in one unit. Design and features of the unit are illustrated and described in detail. Adaptable to heating plants using H. R. T. or water tube boilers rated at from 50 to 600 boiler hp.

No. 2075—COILS: Standard Galvanizing Co., 2611-2619 W. Van Buren St., Chicago, Ill. 20 p. data book on air conditioning coils, hot dipped after fabrication, giving information on construction, capacity curves at various face velocities, data on unit type and blast type coils and header construction, and giving sample problems.

No. 2076—COMPRESSORS: Worthington Pump & Machinery Corp., Harrison, N. J. 8 p.-bulletin on vertical two stage air cooled air compressors, describing details of construction, control and drives.

No. 2077—CONDENSING UNITS: General Electric Co., Air Conditioning Dept., Bloomfield, N. J. Data sheet giving specifications and ratings for condensing units for air conditioning.

No. 2078—CONDENSING UNITS: Reliance Refrigerating Machine Co., 3401 N. Kedzie Ave., Chicago, Ill. 16 p. bulletin on self-contained condensing units for commercial refrigeration duty, for use with methyl chloride, "Freon" and sulphur dioxide in sizes from ⅓ to 2 hp in the air cooled type, and ½ to 7½ hp in the water cooled type. Also, condensing units for air conditioning duty in sizes from 1 to 60 hp. General specifications are given and detailed information on each of the different models is presented.

No. 2079—CONTROLLERS: Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Wayne & Roberts Aves., Philadelphia, Pa. 6 p. folder briefly describing the features of air operated controllers for process work.

No. 2080—CONVECTORS: Modine Mfg. Co., 17th St., Racine, Wis. 32 p. catalog of copper convectors, with foreword on heating and air conditioning and the split system. Information is included on cast grilles available in four elementary designs which enable combination design to fit the architectural requirements of the room. Construction details and installation instructions for concealed, recessed, floor cabinet, and wall cabinet convectors are given, and the heating unit itself is described. Typical specifications, capacities and dimensions are presented.

No. 2081—DUCT WORK: The American Rolling Mill Co., 703 Curtis St., Middletown, O. 4 p. leaflet describing the importance of duct work, "the highway of air travel through which flows conditioned air to provide summer or winter comfort."

No. 2082—FANS: The Emerson Electric Mfg. Co., 502 N. 1st St., St. Louis, Mo. (a) 16 p. catalog illustrating and describing ceiling fans. (b) 8 p. catalog on air circulators, describing different styles of mounting. (c) folder on exhaust fans, describing features and advantages of attic ventilation.

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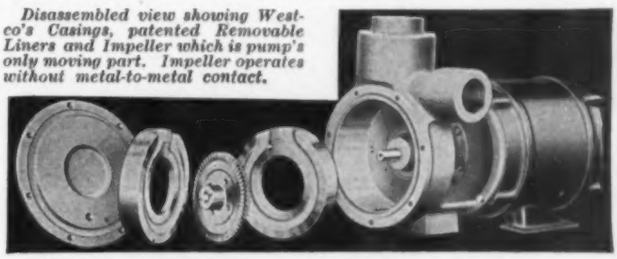

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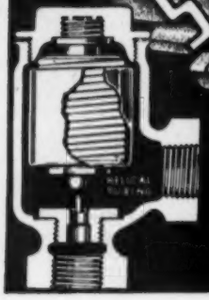

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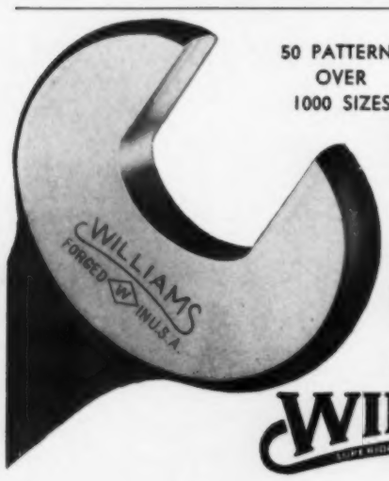

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(d) folder describing complete line of ventilating fans, and showing installations.

No. 2083—FORCED AIR FITTINGS: The Cincinnati Sheet Metal & Roofing Co., 230 E. Front St., Cincinnati, O. 26 p. pocket size catalog of "Ajax" forced air fittings and accessory equipment.

No. 2084—GAS ENGINES: Worthington Pump & Machinery Corp., Harrison, N. J. 8 p. bulletin on vertical four cycle gas engines, describing features and giving specifications and dimensions.

No. 2085—HEATING SPECIALTIES: Gorton Heating Corp., Cranford, N. J. 4 p. bulletin on changing hot water heating systems to vapor equalizing systems without changing the grade of the flow mains, with instructions and description of the specialties.

No. 2086—HEATING SPECIALTIES: Kainer & Co., 761 W. Mather, Chicago, Ill. 12 p. bulletin on heating specialties, containing information on automatic equipment for hot water heating systems.

No. 2087—LUBRICATION: The Texas Co., 135 E. 42nd St., New York, N. Y. 12 p. issue of "Lubrication," Vol. 22, No. 6, devoted to electric refrigeration and air conditioning, discussing the theory of refrigeration, lubrication procedure, types of lubricating systems, and the chemistry of refrigeration as it affects lubrication of equipment. Photographs and sectional views of compressors and condensing units of various types are reproduced, showing method of lubrication.

No. 2088—PIPE AND SHEETS: Republic Steel Corp., Republic Bldg., Cleveland, O. 4 p. issue of "Toncan Topics," Vol. 5, No. 6, including brief paragraphs on the application of "Toncan" pipe and sheets in heating, ventilating and air conditioning.

No. 2089—POWER TRANSMISSION AND PACKING: E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa. 32 p. issue of "Research Illustrated," a publication devoted to presenting the findings of this company's research on power transmission and packing problems. Included is information on relation of motor torque to belt stress, effect of pulsating loads on belts, causes and cures of the pitting of stainless steel by leather, and questions and answers on practical transmission and packing problems.

No. 2090—PROPORTIONING: D. W. Haering & Co., Inc., 3408 W. Monroe St., Chicago, Ill. 10 p. booklet on the art of proportioning, describing the principles and applications of liquid proportioning units employing the fluid piston principle. Several types of proportioning units for handling various process liquids are described.

No. 2091—PSYCHROMETERS: Julien P. Friez & Sons, Inc., 4 N. Central St., Baltimore, Md. Data sheet presenting results of tests made on comparative errors of different types of psychrometers and instruments sensing relative humidity directly.

No. 2092—PUMPS: Worthington Pump & Machinery Corp., Harrison, N. J. (a) 6 p. bulletin on "Monobloc" centrifugal pumping units for heads up to 250 ft., showing construction and giving ratings. (b) 6 p. bulletin on pressed steel frame mounted centrifugal pumps, explaining construction and giving ratings and dimensions. (c) 8 p. bulletin on single stage and two stage horizontal drive vacuum pumps in belt driven and steam driven types, equipped with feather valves. (d) 4 p. bulletin on horizontal duplex steam pump and receiver sets with valve plate type pump and automatic receiver. (e) 4 p. bulletin on vertical vacuum pumps, single stage and two stage, for canning and industrial services, equipped with feather valves.

No. 2093—RADIATION: Slater Mfg. & Engrg. Co., 230 Congress St., Boston, Mass. Leaflet describing cast iron baseboard radiation installed behind baseboard, out of sight.

No. 2094—REFRIGERATION AND AIR CONDITIONING SUPPLIES: Forslund Pump & Machinery Co., 3033 Main St., Kansas City, Mo. 171 p. catalog of wholesale refrigeration and air conditioning supplies for domestic and commercial equipment, with discount sheet.

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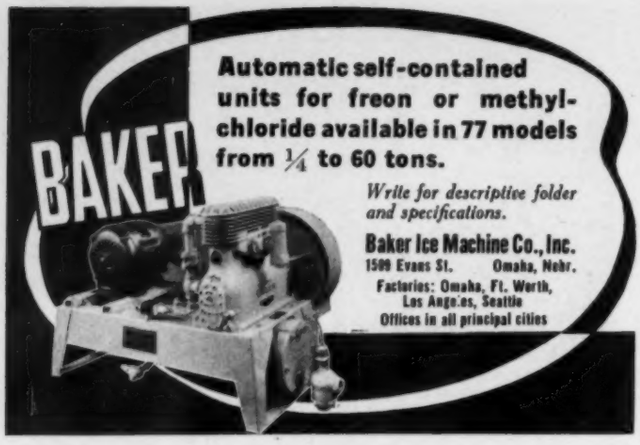
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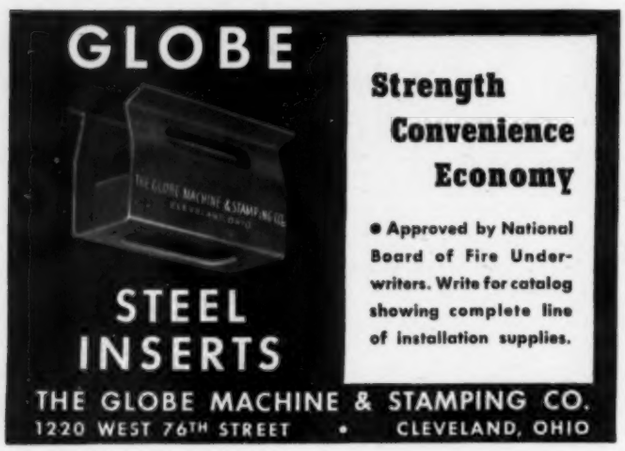
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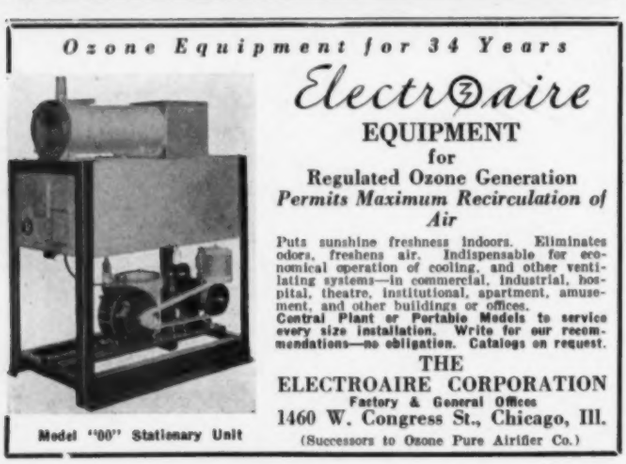
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No. 2097—REGISTERS AND GRILLES: The Waterloo Register Co., Waterloo, Ia. 40 p. catalog of air conditioning registers and grilles of various types, giving illustrations and descriptions of each, tables of free areas, performance curves, graphs of spread of air flow, information on accessory equipment, and list prices.

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